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Original article

Factors related to physical functioning decline after cardiac surgery in older patients: A multicenter retrospective study

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ABSTRACT

Background: As few studies have examined physical functioning changes after cardiac surgery, the factors related to the decline in physical functioning remain unclear. This study aimed to investigate the factors related to physical functioning decline after cardiac surgery in older patients.
Methods: The final study sample consisted of 523 older (≥65 years) patients (age 74.2 ± 6.1 years, 66% male) who underwent cardiac surgery at 8 Japanese institutions. We excluded patients who were unable to walk independently or had a slow gait speed (<0.8 m/s) before surgery, and those who were unable to regain independent walking after surgery. We divided the patients into two groups, a decline-in-gait-speed group and a non-decline-in-gait-speed group, according to whether their gait speed was less than 0.8 m/s at discharge. We analyzed patients' clinical characteristics to identify the factors that predicted the postoperative decline in gait speed.
Results: Eighty-nine patients (17.0%) showed a postoperative decline in gait speed. Multivariate logistic regression analysis showed that the following factors predicted a postoperative decline in gait speed: age [odds ratio (OR) 1.06, 95% confidence interval (CI) 1.02–1.11]; estimated glomerular filtration rate (OR 0.98, CI 0.96–0.99); preoperative gait speed (OR 0.01, CI 0.00–0.08); and the postoperative day on which the patient could walk independently (OR 1.08, CI 1.02–1.14).
Conclusions: Physical functioning declined in 17% of patients after surgery. The decline could be predicted by several clinical factors, including some that are modifiable. These results suggest that further interventional research on rehabilitation before and after cardiac surgery for older patients might help overcome the decline in physical functioning.

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Introduction

According to the May 2017 population estimate by the Statistics Bureau of the Ministry of Internal Affairs and Communications, 35 million Japanese people, approximately 28% of the population, were >65 years of age [1]. Japan has thus become the first super-aged society that no other country in the world has experienced. To date, more than 60,000 patients in Japan undergo cardiac surgery annually [2], but as the population ages, the absolute number of older patients undergoing such surgery is increasing.

Functional reserves decrease in many organ systems as people age, and it is sometimes difficult to protect the body from the stress of surgical invasion. Indeed, older age has been reported as a strong risk factor for postoperative morbidity and mortality [3–6], which are major concerns related to surgical outcomes. It is therefore logical that previous studies aimed to identify preoperative factors that could predict postoperative morbidity and mortality in older patients undergoing cardiac surgery and whether (and what) interventions could reduce these risks [7,8].

The stress of surgical intervention not only affects the postoperative morbidity and mortality rates among elderly patients, it may also have a serious impact on the decline in physical functioning. For older adults, declining physical functioning could cause serious problems with activities of daily living (ADL) and quality of life [9,10]. Nevertheless, few studies have addressed alterations in patients' physical functioning after cardiovascular surgery, and little has been done to identify factors that might be related to such changes.

The aim of this study was to investigate factors related to physical functioning decline after cardiac surgery in older patients. We therefore conducted a multicenter, retrospective study of older patients who had undergone cardiac surgery.

Materials and methods

Study design and participants

We retrospectively examined older patients (≥65 years) who underwent cardiac surgery at eight Japanese institutions participating in the Cardiovascular Surgery Physiotherapy Network between September 2013 and March 2015. This network is a collaborative group that focuses on research and education in the field of cardiac surgery rehabilitation in Japan. This study recruited 23 patients from Kitano Hospital, The Tazuke Kofukai Medical Research Institute; 38 from Fukuyama Cardiovascular Hospital; 89 from Higashi Takarazuka Satoh Hospital; 24 from Shizuoka Medical Center; 50 from St. Luke's International Hospital; 205 from Sakakibara Heart Institute; 213 from Kishiwada Tokushukai Hospital; and 113 from The Sakakibara Heart Institute of Okayama as candidates to study and to generate data for statistical analyses. All eligible patients were asked to provide informed consent. The exclusion criteria were (1) emergency surgery; (2) transcatheter aortic valve replacement; (3) unable to walk independently before surgery or unable to regain independent walking after surgery; (4) slow gait speed before surgery (<0.8 m/s); and (5) New York Heart Association (NYHA) classification IV before surgery. Finally, 523 patients (age 74.2 ± 6.1 years, 66% male) were included in the study (Fig. 1).

The study was conducted in accordance with all regulations of the Declaration of Helsinki. The study protocol was approved by the ethics committee of the Cardiovascular Surgery Physiotherapy Network (No. 16001).

Progression of postoperative rehabilitation

All patients started rehabilitation under the supervision of physical therapists starting the first postoperative day. It was conducted according to the Japanese Circulation Society guidelines for the rehabilitation of patients with cardiovascular disease [11]. Briefly, the early postoperative rehabilitation program included getting out of bed (e.g. sitting on the edge of the bed, sitting on a chair), standing at the bedside, stepping at the bedside, and walking within the intensive care unit.

The indicators of postoperative progression of rehabilitation were the postoperative day on which rehabilitation started and the number of days until the patient regained his or her ability to walk 100 m independently. The definition of independent walking in this study was walking without assistance or supervision from another person, although the patient could use an assistive device (e.g. a cane) if necessary.

Clinical characteristics and measurements

The following clinical characteristics were obtained from the patients' medical records and were used as preoperative variables: age, sex, body mass index, type of operation, operation time, aortic cross-clamp time, cardiopulmonary bypass time, mechanical ventilation time, percent predicted vital capacity, percent predicted forced expiratory volume in 1 s, smoking status, comorbidities (hypertension, diabetes mellitus, dyslipidemia), and NYHA functional classification; laboratory data comprising estimated glomerular filtration rate (eGFR), hemoglobin, albumin, and C-reactive protein; transthoracic echocardiography data (left

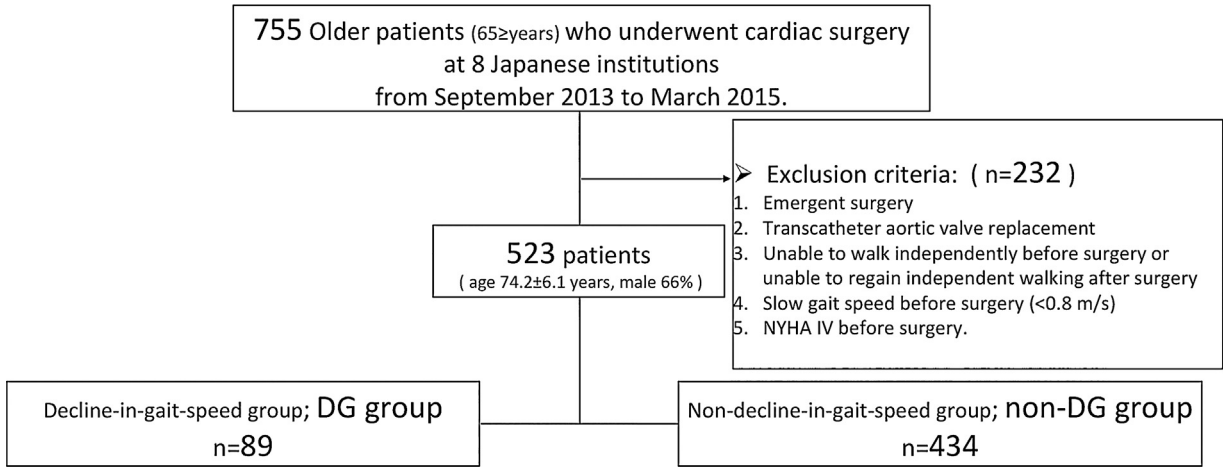

Fig. 1. Flow diagram of the patient selection process in this study. A total of 523 older patients who underwent cardiac surgery at 8 Japanese institutions were analyzed in this study. NYHA, New York Heart Association.

ventricular ejection fraction, left atrial dimension); and the Barthel index as a measure of ADLs. We also investigated postoperative length of hospital stay.

Physical performance measurement

Gait speed, which is the most frequently used physical performance measure in older adults [12–14], was assessed before surgery and at discharge, as described previously [15,16]. Briefly, a 4-m straight course without obstacles was prepared. Patients were instructed to "walk to the other end of the course at your usual pace." Patients could use an assistive device (e.g. a cane) if they usually used one. Each patient was timed twice, and the faster of the two was used for the analyses.

Statistical analysis

The normality of the variables was assessed using the Shapiro–Wilk test. The participants were divided into two groups: a decline-in-gait-speed (DG) group, and a non-decline-in-gait-speed (non-DG) group. A decline in gait speed was defined as a walking speed of <0.8 m/s at discharge (the cut-off value was defined based on that in previous studies [15,16]). Unpaired *t*-tests, Mann–Whitney *U* tests, and χ^2 tests were performed to compare the clinical characteristics between the two groups. Multivariate logistic regression analysis was undertaken to identify the predictors of a postoperative decline in gait speed. Statistical significance was set at $p < 0.05$ for all analyses. Statistical analyses were performed using SPSS statistics version 22 (IBM, Inc., Armonk, NY, USA).

Results

Of the 897 potential patients, 374 met the exclusion criteria. Thus, 523 patients were included in the analysis. The mean [±standard deviation (SD)] age of the patients was 74.2 ± 6.0 years, and 66.0% were male. The types of operation varied: 13.2% of patients underwent isolated off-pump coronary artery bypass grafting (CABG), 9.8% isolated on-pump CABG, 21.8% isolated valve replacement or valvuloplasty, and 39.8% complex surgery (e.g. CABG plus valve replacement).

In all, 89 patients (17%) had a gait speed of <0.8 m/s at discharge (DG group). The clinical characteristics of the DG and non-DG groups are shown in Table 1. Compared with the non-DG group, the DG patients were significantly older ($p < 0.001$), more likely to be female ($p = 0.032$), and had a higher NYHA functional classification ($p < 0.001$). The DG patients also had a lower eGFR ($p = 0.002$), lower hemoglobin level ($p = 0.002$), and slower gait speed before surgery ($p = 0.002$) than the non-DG patients. The postoperative day on which patients started rehabilitation was similar in the two groups ($p = 0.211$), but the postoperative day on which patients walked independently was significantly later in the DG group ($p = 0.004$).

Table 2 shows the results of the univariate and multivariate logistic regression analyses for the decline in gait speed after surgery. Age [odds ratio (OR) 1.06, 95% confidence interval (CI)

Table 1
Clinical characteristics of the decline-in-gait-speed (DG) and non-decline-in-gait-speed (non-DG) groups.

	Overall ($n = 523$)	DG group ($n = 89$)	Non-DG group ($n = 434$)	*p*-value
Age (years)	74.2 ± 6.0	77.1 ± 6.0	73.6 ± 6.0	<0.001
Sex (male, %)	66.0	56.2	68.0	0.032
BMI	23.0 ± 3.3	22.8 ± 3.5	23.1 ± 3.2	0.443
Type of operation (%)				0.379
Isolated off-pump CABG	13.2	10.1	13.8	
Isolated on-pump CABG	9.8	12.4	9.2	
Isolated valve replacement or valvuloplasty	21.8	15.7	23.0	
Isolated vascular surgery	15.5	18.0	15.0	
Complex surgery	39.8	43.8	38.9	
Operation time (min)	291.8 ± 92.0	308.5 ± 100.0	288.4 ± 90.0	0.061
Aortic cross clamp time (min)	105.0 ± 42.1	103.5 ± 50.5	105.3 ± 40.3	0.770
Cardiopulmonary bypass time (min)	150.7 ± 53.7	153.1 ± 48.9	150.2 ± 54.7	0.692
Mechanical ventilation time (min)	975.0 (610.5–1331.5)	1077.0 (608.0–1445.0)	943.5 (613.5–1320.0)	0.143
Smoking status (former or current, %)	44.6	39.3	45.8	0.261
Hypertension (yes, %)	71.7	75.3	71.1	0.428
Diabetes mellitus (yes, %)	31.7	39.3	30.2	0.091
Dyslipidemia (yes, %)	50.9	50.6	50.9	0.951
NYHA classification (%)				<0.001
I	45.3	44.4	50.9	
II	39.4	38.3	44.1	
III	6.5	17.3	5.0	
eGFR (ml/min/1.73m^2)	57.3 ± 17.8	51.3 ± 16.7	58.5 ± 17.8	0.001
Hb (g/dl)	12.7 ± 1.6	12.2 ± 1.5	12.8 ± 1.6	0.002
Alb (g/dl)	4.2 ± 1.9	4.4 ± 4.6	4.1 ± 0.5	0.495
CRP (mg/dl)	0.4 ± 1.7	0.5 ± 1.0	0.4 ± 1.7	0.837
LVEF (%)	61.1 ± 11.1	59.0 ± 14.4	61.5 ± 10.3	0.132
LAD (mm)	40.5 ± 8.4	40.2 ± 8.4	40.5 ± 8.4	0.796
%VC	91.1 ± 18.1	88.0 ± 18.6	91.8 ± 17.9	0.094
FEV 1.0%	79.0 ± 13.0	77.1 ± 12.7	79.4 ± 13.1	0.161
Barthel index	99.2 ± 6.0	99.6 ± 1.9	99.2 ± 6.5	0.531
Preoperative gait speed (m/s)	1.1 ± 0.2	1.0 ± 0.1	1.1 ± 0.2	0.002
Postoperative day that started rehabilitation (day)	1.3 ± 1.9	1.8 ± 4.3	1.2 ± 0.7	0.211
Postoperative length of hospital stay (day)	18.4 ± 20.2	21.3 ± 17.3	17.8 ± 20.7	0.113
Postoperative day that patient walked independently (day)	4.7 ± 4.0	6.6 ± 6.9	4.5 ± 3.4	0.004

Alb, albumin; BMI, body mass index; CABG, coronary artery bypass grafting; CRP, C-reactive protein; eGFR, estimated glomerular filtration rate; FEV 1.0%, percent predicted forced expiratory volume in 1 s; Hb, hemoglobin; LAD, left atrial dimension; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; %VC, percent predicted vital capacity.

Table 2
Logistic regression analysis considering the occurrence of declining gait speed postoperatively.

	Univariate regression analysis			Multivariate regression analysis[a]		
	OR	95%CI	*p*-value	OR	95%CI	*p*-value
Age (years)	1.08	1.04–1.12	<0.001	1.06	1.02–1.11	0.009
Female	1.66	1.04–2.64	0.034			
BMI	0.97	0.91–1.04	0.442			
Type of operation		–				
Isolated off-pump CABG	Reference	–				
Isolated on-pump CABG	1.83	0.70–4.82	0.219			
Isolated valve replacement or valvuloplasty	0.93	0.38–2.29	0.880			
Isolated vascular surgery	1.64	0.68–3.99	0.275			
Complex surgery	1.54	0.70–3.36	0.280			
Operation time (min)	1.00	1.00–1.00	0.095			
Aortic cross clamp time (min)	1.00	0.99–1.01	0.770			
Cardiopulmonary bypass time (min)	1.00	1.00–1.01	0.691			
Mechanical ventilation time (min)	1.00	1.00–1.00	0.002			
Smoking status[b]	0.75	0.47–1.18	0.209			
Hypertension	1.23	0.77–2.05	0.436			
Diabetes mellitus	1.59	1.00–2.52	0.048			
Dyslipidemia	0.80	0.60–1.48	0.799			
NYHA classification						
I	Reference					
II	0.99	0.59–1.67	0.982			
III	3.93	1.82–8.48	<0.001			
eGFR (ml/min/1.73m^2)	0.98	1.00–0.99	0.001	0.98	0.96–0.99	0.023
Hb (g/dl)	0.80	0.69–0.92	0.002			
Alb (g/dl)	1.06	0.96–1.18	0.254			
CRP (mg/dl)	1.01	0.89–1.16	0.831			
LVEF (%)	0.98	0.97–1.00	0.098			
LAD (mm)	1.00	0.97–1.02	0.815			
%VC	0.99	0.98–1.00	0.095			
FEV 1.0%	0.99	0.97–1.01	0.986			
Barthel index	1.02	0.95–1.10	0.558			
Preoperative gait speed (m/s)	0.01	0.00–0.04	<0.001	0.01	0.00–0.08	<0.001
Postoperative length of hospital stay (day)	1.00	0.97–1.02	0.815			
Postoperative day that patient regain independent walking (day)	1.09	1.04–1.15	<0.001	1.08	1.02–1.14	0.014

Alb, albumin; BMI, body mass index; CABG, coronary artery bypass grafting; CI, confidence interval; CRP, C-reactive protein; eGFR, estimated glomerular filtration rate; FEV 1.0%, percent predicted forced expiratory volume in 1 s; Hb, hemoglobin; LAD, left atrial dimension; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; OR, odds ratio; %VC, percent predicted vital capacity.
[a] Adjusted for gender, type of operation, mechanical ventilation time, diabetes mellitus, NYHA, Hb, operation time, and postoperative length of hospital stay.
[b] Smoking status: former or current vs. never.

1.02–1.11], eGFR (OR 0.98, CI 0.96–0.99), preoperative gait speed (OR 0.01, CI 0.00–0.08), and postoperative day that the patient regained independent walking (OR 1.08, CI 1.02–1.14) were the predictors of a decline in gait speed after surgery after being adjusted for the patient's sex, operation type, operation time, mechanical ventilation time, presence of diabetes mellitus, hemoglobin level, NYHA functional classification, and postoperative length of hospital stay.

Discussion

To the best of our knowledge, this is the first study to investigate the factors related to physical functioning decline after cardiac surgery in older patients using multicenter cohort data. We found that 17% of patients showed a decline in gait speed after surgery despite preservation of their normal gait speed before surgery. Age, eGFR, preoperative gait speed, and the postoperative day that the patient regained independent walking were found to be independent predictors of the decline in gait speed. We excluded patients whose preoperative walking ability was already highly impaired (gait speed of <0.8 m/s, unable to walk independently, or unable to walk at all because of the severity of the heart failure). Therefore, the results clearly reflect the factors related to the decline in physical function caused by the stress of the surgical invasion.

The few studies that have examined the factors related to the decline in physical function after cardiac surgery have used different methods. Nevertheless, some related factors have been identified. For example, older age is already a known risk factor for reduced physical functioning after cardiac surgery [17]. Govers et al. [18] showed that 44.9% of older patients who underwent cardiothoracic surgery still had reduced ADL scores 3 months afterward, indicating that this proportion is higher for the elderly. Older patients who show a decline in their physical functioning also tend to have poor renal function [19]. A possible explanation for the relation between renal function and postoperative physical functioning decline is that patients with kidney dysfunction already show decreased motor function due to the severity of their illness [20] and tend to make slower progress in their rehabilitation after cardiac surgery [21]. These studies support our results and suggest that older age and renal function play important roles in the physical functioning decline after cardiac surgery.

No study to date has examined the preoperative gait speed or the postoperative day that patients regain independent walking as factors related to the decline in physical function after cardiac surgery. Hence, our study reveals new findings. Although no previous study can clearly explain this mechanism, several studies provide some hints. First, walking speed is considered a major explanatory factor of frailty [22], and it has been reported that frailty is strongly related to various adverse outcomes including morbidity and mortality [14,23,24]. Frail patients are considered to have low physiological resistance to major physical invasions such as cardiac surgery [25–27], and frailty may have a similar influence on physical functioning.

Several studies have examined the relationship between the postoperative day that patients regain independent walking and the decline in physical function after cardiac surgery. Schweickert et al. [28] reported that comprehensive rehabilitation, including early mobilization, improved ADL recovery among patients who entered the intensive care unit on a ventilator. Takahashi et al. [29] reported a relationship between in-hospital step counts before discharge and the postoperative day that patients regained independent walking after cardiac surgery. These findings imply that decreased physical activity and participation in ADLs while in hospital due to a delay in the progression of early-phase rehabilitation or in regaining independent walking may explain the decline in physical functioning after surgery. We cannot provide evidence to support this suggestion, however, because it is beyond our research objectives, and we did not collect data on physical activity. We do, however, emphasize the importance of further research on the relation between reduced physical functioning after cardiac surgery and in-hospital physical activity.

We acknowledge the limitations of this study. All registered institutions in this research cohort contained facilities wherein physical therapists provided rehabilitation to all cardiac surgical patients. Therefore, this cohort may not be representative of all Japanese cardiac surgery patients and may underestimate the incidence of postoperative physical functioning decline. As the results may not be generalizable, the study should be replicated using a sample selected from larger, more diverse participating facilities.

Conclusions

Our study revealed that 17% of patients experienced a decline in physical functioning after cardiac surgery despite its preservation before surgery. We also identified age, eGFR, preoperative gait speed, and the postoperative day that patients regained independent walking as risk factors for this decline. An important discovery was that it is theoretically possible to provide interventions to improve the preoperative gait speed and the postoperative day that patients regained independent walking. Our findings indicate the importance of conducting interventional rehabilitation studies before and after cardiac surgery in older patients.

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Conflict of interest

The authors declare that there is no conflict of interest

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