

[Original]

The Relationship Between Preoperative Frailty Risk as Assessed by the Hospital Frailty Risk Score and the Outcome at Discharge in Coronary Artery Bypass Grafting (CABG) Patients: A Retrospective Observational Study Using the Diagnosis Procedure Combination Database

Nozomu SUGIMOTO^{1*}, Ryutaro MATSUGAKI², Satoshi KUHARA¹, Hanaka IMAMURA², Hideaki ITOH⁵, Masaru ARAKI³, Kiyohide FUSHIMI⁴, Shinya MATSUDA² and Satoru SAEKI⁵

¹ Department of Rehabilitation, University Hospital of Occupational and Environmental Health, Japan. Yahatanishi-ku, Kitakyushu 807-8556, Japan

² Department of Preventive Medicine and Community Health, School of Medicine, University of Occupational and Environmental Health, Japan. Yahatanishi-ku, Kitakyushu 805-8555, Japan

³ Department of Cardiology, Tagawa Municipal Hospital, Japan. Hoshii, Tagawa 825-0005, Japan

⁴ Department of Health Policy and Informatics, Tokyo Medical and Dental University Graduate School, Japan. Bunkyo-ku, Tokyo 113-8510, Japan

⁵ Department of Rehabilitation Medicine, University of Occupational and Environmental Health, Japan. Yahatanishi-ku, Kitakyushu 807-8556, Japan

Abstract : The relationship between the Hospital Frailty Risk Score (HFRS)-based frailty risk and outcomes after coronary artery bypass grafting (CABG) is yet unclear. The objective of this study was to investigate the relationship between preoperative frailty risk as assessed by the HFRS and postoperative outcomes in patients undergoing CABG. This observational study used the diagnosis procedure combination (DPC) system in Japan (2014–2017). In total, 35,015 adults aged ≥ 65 years and diagnosed with angina pectoris and acute myocardial infarction who had undergone CABG were enrolled. We investigated the association between the HFRS-based frailty risk and the home discharge rate, as well as the prevalence of complications. Multilevel logistic regression analysis revealed that having an HFRS ≥ 5 was a determinant of lower home discharge rate (odds ratio [OR] 0.60, 95% confidence interval [CI] 0.49–0.74, $P < 0.01$), aspiration pneumonia (OR 2.25, 95%CI 1.27–3.96, $P < 0.01$) and disuse syndrome (OR 1.90, 95%CI 1.23–2.94, $P < 0.01$). Preoperative stratification of frailty risk using HFRS may help in predicting postoperative progress and in planning postoperative rehabilitation.

Keywords : frailty, cardiac surgery, home discharge rate, complications, diagnosis procedure combination.

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Introduction

There has been a steady rise in the volume of cardiovascular surgeries performed in Japan on older patients

with a high risk profile and those who suffer from comorbidities [1]. Frailty is a multifaceted syndrome that includes physical, mental, and social factors. It is also associated with increased vulnerability due to a decline

*Corresponding Author: Nozomu SUGIMOTO, Department of Rehabilitation, University Hospital of Occupational and Environmental Health, 1-1 Iseigaoka, Yahatanishi-ku Kitakyushu 807-8556, Japan, Tel: +81-93-603-1611, Fax: +81-93-603-6691, E-mail: sugimoto55351@clnc.uoeh-u.ac.jp

in physiological reserves in old age, which can result in the need for nursing care and death [2]. Frailty is also associated with postoperative mortality, complications, and prolonged postoperative cardiac rehabilitation in patients after cardiac surgery [3]. Frailty must therefore also be considered during cardiovascular surgery.

Frailty has been defined using the Cardiovascular Health Study (CHS) criteria based on Fried's phenotypic model, and the Frailty Index is grounded on the concept of disability accumulation, wherein the combined impact of multiple individual disabilities is taken into account [4,5]. These models necessitate in-person evaluation, making it challenging to assess frailty in numerous elderly patients with acute illnesses or dementia. There is no gold standard assessment for evaluating frailty due to the wide variety of assessment indicators that need to be measured.

The Hospital Frailty Risk Score (HFRS), a frailty risk assessment score recently developed based on the International Classification of Disease, 10th Revision (ICD-10) diagnosis codes, can stratify patients at risk for preoperative frailty [6]. Data from over 1 million older patients in the UK, obtained through electronic health records, were used to develop this assessment method, which was subsequently validated against the Fried and Rockwood frailty scales [6]. There are few reports in cardiovascular surgery on the relationship between frailty as assessed by the HFRS based on the ICD-10 diagnostic codes and the prognosis of postoperative patients with valvular disease [7], and the relationship between frailty risk and the outcome at discharge after coronary artery bypass grafting (CABG) has not been determined. Stratification of postoperative outcomes through preoperative assessment may promote a comprehensive approach and provide insights into postoperative outcomes for high-risk patients.

The objective of this study was to investigate the relationship between preoperative frailty risk as assessed by the HFRS and postoperative outcomes in patients who had undergone CABG.

Methods

Study design and participants

This retrospective cohort study utilized the Japanese Diagnosis Procedure Combination (DPC) database.

Patients had been diagnosed according to the ICD-10 codes. Patients discharged from April 2014 to March 2020 were enrolled, including adults aged ≥ 65 years who had been diagnosed with angina pectoris (ICD-10 codes: I20) and acute myocardial infarction (ICD-10 codes: I21) and who had undergone CABG (K552). We excluded patients who were admitted outside their homes, such as at recovery hospitals or institutions.

This study was approved by the institutional review board of the University of Occupational and Environmental Health, Japan (No. R2-007). The procedures adhered to the 1964 Helsinki declaration and its later amendments. The requirement for informed consent was waived due to the retrospective nature of the study.

Data source

The DPC is a case-mix patient classification system that was launched in 2002 by the Ministry of Health, Labour, and Welfare of Japan. Details regarding the DPC database have been previously reported [8-10].

The following data were collected from the database: age, sex, body mass index, coronary risk factors (hypertension [ICD-10 code: I10], dyslipidemia [ICD-10 code: E785], diabetes mellitus [ICD-10 codes: E10-E11], smoking history), heart failure (ICD-10 code: I50), stroke (ICD-10 codes: I60-I64), chronic renal failure (ICD-10 codes: N18, I12-I13), chronic obstructive pulmonary disease (ICD-10 codes: J42, J44), Charlson comorbidity index [11,12], ischemic heart disease (angina pectoris [ICD-10 code: I20] and acute myocardial infarction [ICD-10 code: I21]), on-pump CABG (K552), Barthel Index (BI) at admission, and hospital case volume.

Calculation of the Hospital Frailty Risk Score

The HFRS used to assess the frailty risk is based on the ICD-10 codes [6]. It was calculated for each patient based on 109 ICD-10 codes (the first three characters) at the time of admission prior to surgery. HFRS points were assigned according to the corresponding 109 ICD-10 codes, with ICD code F00 (dementia in Alzheimer's disease) being the highest (7.1 points) and R50 (fever of unknown origin) being the lowest (0.1 points). Details on how to calculate HFRS are described in the original HFRS study [6]. In this study, the frailty risk was classified as low risk (HFRS < 5),

intermediate risk (HFRS 5–15), or high risk (HFRS > 15), based on the HFRS.

Outcomes

The primary outcome was the home discharge rate. The secondary outcomes were the complications—aspiration pneumonia (ICD-10 code: J690), stroke (ICD-10 codes: I60–I64), delirium (ICD-10 code: F05), disuse syndrome (ICD-10 code: M625), heart failure (ICD-10 codes: I50, I971), and sepsis (ICD-10 codes: A40, A41, and T814).

Statistical analysis

Continuous variables are expressed as median [interquartile range (IQR)]. Categorical variables are expressed as numbers and percentages. The patients were divided into groups based on the assessment of the frailty risk using HFRS, and a comparison of clinical characteristics and preoperative physical function was performed. The clinical characteristics between the two groups were compared using the Mann–Whitney U and Fisher's exact tests and the unpaired Student's *t*-test. Multilevel logistic regression analysis was performed to analyze the association between the frailty risk and outcomes. We utilized a multilevel logistic regression analysis of random-intercept and fixed-slope models, accounting for the nested structure of healthcare institutions. Specifically, based on previous studies, the following factors related to outcomes in cardiovascular surgery patients were analyzed as independent variables: age, sex, body mass index, smok-

ing history, disease, on-pump CABG, Charlson comorbidity index, comorbidities (hypertension, diabetes mellitus, dyslipidemia, heart failure, stroke, chronic renal failure, and chronic obstructively pulmonary diseases), BI at admission, and hospital case volume [13,14]. Dependent variables like the home discharge rate and complications (aspiration pneumonia, stroke, delirium, disuse syndrome, heart failure, and sepsis) were also analyzed. Statistical significance was set at $P < 0.05$. All statistical analyses were performed using Stata software (Stata Statistical Software: Release 16; StataCorp LLC, TX).

Results

In this study we enrolled 40,077 adults aged ≥ 65 years who had been diagnosed with angina pectoris and acute myocardial infarction and had undergone CABG. After excluding 5,062 patients who were admitted from outside their homes, such as recovery hospitals or institutions, 35,015 patients were finally included (Figure 1).

The frailty risk, based on HFRS, was classified as low (HFRS < 5) in 34,382 (98%) and intermediate (HFRS 5–15) in 633 (2%) patients. There were no high-risk patients (HFRS > 15).

The clinical characteristics of the patients in the low (LFR) and intermediate frailty risk (IFR) groups are shown in Table 1. The patients in the IFR group were significantly older; had a lower body mass index; higher rates of dyslipidemia, heart failure and on-

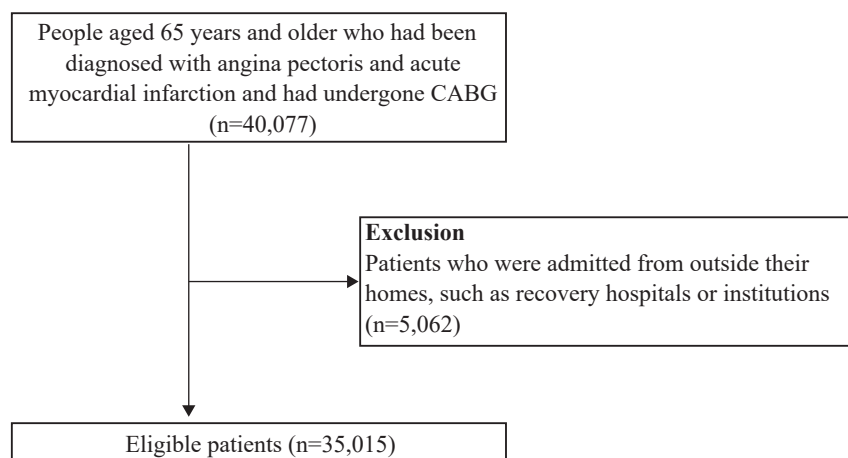


Figure 1. Participant inclusion process in this study. CABG: coronary artery bypass grafting.

Table 1. Characteristics of patients undergoing coronary artery bypass grafting

Variables	Low risk (HFRS <5) (n = 34,382)	Intermediate risk (HFRS 5–15) (n = 633)	<i>P</i> value
	median (IQR) or n (%)	median (IQR) or n (%)	
Age (years)	74.0 (69.0–78.0)	75.0 (70.0–80.0)	<0.01
Female sex	8,115 (23.6)	137 (21.6)	0.25
BMI (kg/m ²)			
<18.5	1,685 (4.9)	52 (8.2)	<0.01
18.5–25	22,302 (64.9)	416 (65.7)	<0.01
>25	9,921 (28.9)	158 (25.0)	<0.01
Disease			
Angina pectoris	30,925 (89.9)	558 (88.2)	0.14
Myocardial infarction	3,457 (10.1)	75 (11.8)	0.14
On-pump CABG	14,907 (43.4)	322 (50.9)	<0.01
Coronary risk factors			
Smoking status (former or current)	15,400 (44.8)	261 (41.2)	0.07
Hypertension	20,301 (59.0)	370 (58.5)	0.76
Diabetes mellitus	14,755 (42.9)	295 (46.6)	0.06
Dyslipidemia	11,291 (32.8)	170 (26.9)	<0.01
Charlson comorbidity index			
0	5,534 (16.1)	11 (1.7)	<0.01
1	11,004 (32.0)	79 (12.5)	<0.01
2	9,588 (27.9)	113 (17.9)	<0.01
≥3	8,256 (24.0)	430 (67.9)	<0.01
Comorbidities			
Heart failure	11,575 (33.7)	176 (27.8)	<0.01
Stroke	977 (2.8)	19 (3.0)	0.81
Chronic renal failure	4,377 (12.7)	324 (51.2)	<0.01
Chronic obstructive pulmonary disease	685 (2.0)	14 (2.2)	0.70
Hospital case volume (cases/year)			
<18	11,572 (33.7)	260 (41.1)	<0.01
19–37	11,377 (33.1)	203 (32.1)	<0.01
38–142	11,433 (33.3)	170 (26.9)	<0.01
Barthel Index (fully independent)	25,071 (72.9)	338 (53.4)	<0.01
HFRS	0 (0–1.4)	5.4 (5.1–6.3)	<0.01
Discharge to home	29,287 (85.2)	425 (67.1)	<0.01
Complication (n, %)			
Aspiration pneumonia	216 (0.6)	15 (2.4)	<0.01
Delirium	418 (1.2)	15 (2.4)	<0.01
Disuse syndrome	1,091 (3.2)	36 (5.7)	<0.01
Heart failure	7,302 (21.2)	140 (22.1)	0.59
Sepsis	372 (1.1)	21 (3.3)	<0.01
Stroke	797 (2.3)	20 (3.2)	0.16

Categorical variables are presented as numbers (%).

IQR: Continuous variables are presented as median, BMI: body mass index, CABG: coronary artery bypass grafting, NYHA: New York Heart Association, HFRS: Hospital Frailty Risk Score, SD: standard deviation.

pump CABG; a higher Charlson comorbidity index; and a lower preoperative BI than those in the LFR group. The patients in the IFR group had significantly lower home discharge rates and higher rates of aspiration pneumonia, disuse syndrome, and sepsis.

Table 2 shows the results of two multivariate logistic regression analyses of the association between the frailty risk and outcomes. Model 1 logistic regression analysis, which was adjusted for age and sex, revealed that having a risk of frailty with an HFRS ≥ 5 was a determinant of a lower home discharge rate (odds ratio [OR] 0.37, 95% confidence interval [CI] 0.31–0.45, $P < 0.01$), aspiration pneumonia (OR 3.17, 95% CI 1.83–5.50, $P < 0.01$), delirium (OR 1.80, 95% CI 1.04–3.11, $P < 0.05$), disuse syndrome (OR 2.27, 95%

CI 1.49–3.46, $P < 0.01$), and sepsis (OR 2.86, 95% CI 1.81–4.52, $P < 0.01$). Model 2 logistic regression analysis, which was adjusted for age, sex, body mass index, coronary risk factors (hypertension, diabetes mellitus, dyslipidemia and smoking history), disease, on-pump CABG, Charlson comorbidity index, comorbidities (heart failure, stroke, chronic renal failure, and chronic obstructively pulmonary diseases), BI at admission, and hospital case volume, revealed that having a risk of frailty with an HFRS ≥ 5 was a determinant of a lower home discharge rate (OR 0.60, 95% CI 0.49–0.74, $P < 0.01$), aspiration pneumonia (OR 2.25, 95% CI 1.27–3.96, $P < 0.01$) and disuse syndrome (OR 1.90, 95% CI 1.23–2.94, $P < 0.01$).

Table 2. Multilevel logistic regression analysis for outcomes according to the hospital frailty risk score

	n	%	Model 1 [†]				Model 2 [‡]			
			OR	95% CI		P	OR	95% CI		P
Discharge to home										
HFRS <5	29,287	85.2	Reference				Reference			
HFRS ≥5	425	67.1	0.37	0.31	0.45	<0.001	0.60	0.49	0.74	<0.001
Aspiration pneumonia										
HFRS <5	216	0.6	Reference				Reference			
HFRS ≥5	15	2.4	3.17	1.83	5.50	<0.001	2.25	1.27	3.96	0.005
Delirium										
HFRS <5	418	1.2	Reference				Reference			
HFRS ≥5	15	2.4	1.80	1.04	3.11	0.035	1.36	0.78	2.39	0.278
Disuse syndrome										
HFRS <5	1,091	3.2	Reference				Reference			
HFRS ≥5	36	5.7	2.27	1.49	3.46	<0.001	1.90	1.23	2.94	0.004
Heart failure										
HFRS <5	7,302	21.2	Reference				Reference			
HFRS ≥5	140	22.1	1.04	0.83	1.30	0.734	1.11	0.87	1.41	0.395
Sepsis										
HFRS <5	372	1.1	Reference				Reference			
HFRS ≥5	21	3.3	2.86	1.81	4.52	<0.001	1.58	0.98	2.55	0.058
Stroke										
HFRS <5	797	2.3	Reference				Reference			
HFRS ≥5	20	3.2	1.20	0.76	1.90	0.432	0.97	0.61	1.55	0.911

[†]Model 1: adjusted for age and sex.

[‡]Model 2: adjusted for age, sex, body mass index, smoking history, disease, on-pump CABG, Charlson comorbidity index, comorbidities (hypertension, diabetes mellitus, dyslipidemia, heart failure, stroke, chronic renal failure, and chronic obstructively pulmonary diseases), activities of daily living, and hospital case volume.

HFRS, Hospital Frailty Risk Score; OR, odds ratio; CI, confidence interval; CABG, coronary artery bypass grafting.

Discussion

In this study, we clarified the association between the frailty risk as assessed by HFRS based on the ICD-10 codes and the home discharge rate and complications in patients who had undergone CABG, using the Japanese DPC database. As far as we are aware, there have been no prior investigations into the relationship between HFRS and postoperative outcomes in patients who underwent CABG. Our findings indicate that HFRS can predict the home discharge rate and complications in patients who undergo CABG. Furthermore, predicting clinical outcomes using HFRS in Japanese CABG patients could potentially be introduced into clinical practice for a simple, early, and systemic assessment of the frailty risk.

The HFRS is an assessment scale that scores frailty risk based on 109 comorbidities, including Alzheimer's disease and gait/movement abnormalities that directly affect functional recovery [6]. The risk of frailty is attributed to a reduced physiological reserve, leading to more comorbidities such as a low physical function and poor nutritional status [15]. Patients with a higher risk of frailty as assessed by HFRS are more likely to have more comorbidities that affect their functional recovery. It has also been reported that patients who are physically frail before surgery may have major complications afterward, and many have been transferred to rehabilitation hospitals or institutions [16].

In this study, we found that patients who were at intermediate risk of frailty with $\text{HFRS} \geq 5$ based on the ICD-10 codes had lower home discharge rates, and higher rates of aspiration pneumonia and disuse syndrome than those at low risk (score of ≤ 5). Comorbidities are risk factors for decreased exercise tolerance and physical function, and poor preoperative physical function is a risk factor for postoperative respiratory complications such as pneumonia, prolonged extubation of the ventilator, disuse syndrome and prolonged postoperative rehabilitation [3,14]. Decreased activity and malnutrition due to decreased physical function can easily lead to oral frailty (dysphagia), and the progression of oral frailty increases the risk of aspiration pneumonia and is associated with a longer hospital stay [17,18]. The relationship between the increasing risk of frailty and the decreased home discharge rate,

as well as an increased incidence of aspiration pneumonia and disuse syndrome, may be complicated by various factors, such as comorbidities and decreased physical and oral functions associated with increased frailty. The onset of postoperative complications such as aspiration pneumonia and disuse syndrome may lead directly to a longer postoperative hospital stay, increasing the likelihood of the patient being transferred to a rehabilitation hospital to improve daily living functions. Preoperative stratification of the frailty risk using HFRS may therefore be useful in the prediction of postoperative complications and early identification of patients who will have difficulty with home discharge. This will help prevent deterioration in the functional prognosis, potentially reduce medical costs, and contribute towards promoting a more intensive and comprehensive approach to postoperative rehabilitation of patients who undergo CABG.

The present study utilized HFRS to evaluate preoperative frailty risk in patients who had undergone CABG. Patients with a high frailty risk ($\text{HFRS} \geq 15$) were not included in the study, given that they might not have been suitable candidates for a highly invasive procedure like CABG. This could have potentially impacted the findings of the study. In addition, prior studies have found that the rates of comorbidity frailty were 33% and 19% in patients with heart failure and ischemic heart disease, respectively, who had undergone CABG. The rate was lower in patients with ischemic heart disease [19,20]. As per previous studies, the HFRS tends to peak at 5 points in several populations, followed by a decrease in the number of patients with higher scores, which aligns with the findings of this investigation [6]. An earlier report indicated that patients with an $\text{HFRS} \geq 5$ have a higher risk of experiencing adverse events relative to those with an $\text{HFRS} < 5$ [21]. Based on these findings, $\text{HFRS} \geq 5$ may be an important predictor of the functional outcome in patients who undergo CABG.

Several limitations were identified in this study. First, the scope of data extraction was confined to the information accessible through the hospital information system; thus, no adjustments were made for the effects of unmeasured confounders such as the physical function and pre-hospital treatment status. Secondly, since the HFRS is based on the ICD-10 codes,

the coding accuracy among individual physicians may be a source of bias. However, the criterion-related validity of medical records based on the ICD-10 codes were validated; therefore, bias due to coding inaccuracies was probably minimal [22]. Finally, the complications used in this study were extracted from the hospital information system as post-hospitalization complications; thus, it was unclear whether they were postoperative complications.

Conclusion

In this study, we found that having a higher frailty risk, as assessed by the HFRS based on the ICD-10 codes, was associated with lower home discharge rates and the development of complications in patients who had undergone CABG. These findings suggest the importance of the preoperative stratification of the frailty risk using HFRS, which may be an important clinical indicator for predicting postoperative progress and planning postoperative rehabilitation in patients who undergo CABG.

Conflict of Interest

The authors declare no conflict of interest.

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