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ORIGINAL ARTICLE

# Length of hospital stay and its impact on subsequent early readmission in patients with acute heart failure: a report from the WET-HF Registry

**Hidenori Moriyama[1] · Takashi Kohno[1] · Shun Kohsaka[1] · Yasuyuki Shiraishi[1] · Ryoma Fukuoka[1] · Yuji Nagatomo[2] · Ayumi Goda[3] · Atsushi Mizuno[4] · Keiichi Fukuda[1] · Tsutomu Yoshikawa[2] · West Tokyo Heart Failure Registry Investigators**

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## Abstract

Heart failure (HF) is characterized by frequent rehospitalization and prolonged hospital stay. Although length of stay has been used as a surrogate marker for hospital performance, its association with early rehospitalization remains unknown. We investigated their precise association using contemporary Japanese HF registry. We analyzed the 2785 acute HF patients who were registered in the West Tokyo Heart Failure registry and discharged or transferred to the recuperation facilities (mean age, 73.8 ± 13.5 years; 60.8% were men). Median length of stay was 15 days (interquartile range, 10–23 days). One-hundred and fourteen patients (4.1%) were readmitted for worsening HF within 30 days after discharge. Thirty-day risk-adjusted HF readmission after a shorter length of stay (1–12 days; the lower tertile within the cohort) was higher than those after intermediate (13–19 days; the middle tertile) [HR 1.71, 95% confidence interval (CI) 1.05–2.77]. Even after a longer length of stay, there tended to be a higher risk of 30-day HF readmission (HR 1.59, 95% CI 0.96–2.65). In conclusion, the Japanese acute HF patients had low rates of early-HF readmission after quite a long length of stay at urban tertiary care centers. Shorter length of stay was associated with increased rates of 30-day HF readmission, while longer length of stay also the same trended. *Clinical Trial Registration*: https://www.umin.ac.jp/icdr/index-j.html. Unique identifier: UMIN000001171.

**Keywords** Heart failure · Length of stay · Readmission · Registry-based study

## Introduction

Heart failure (HF) is associated with high mortality, frequent readmission, and prolonged length of hospital stay [1, 2]. Additionally, it imposes a large economic burden on the health care system, which has been estimated to be $108 billion annually worldwide [3]. Readmission shortly after discharge has been considered as a surrogate measure for hospital performance; it is considered preventable, and is also thought to be related to subsequent clinical outcomes. Indeed, among Medicare beneficiaries hospitalized for HF, 30-day readmission was associated with a higher risk of subsequent all-cause mortality and HF readmission, longer cumulative length of stay, and higher cumulative cost [4]. The rates of readmission in patients with HF remain stable, and even more than 20% of patients discharged with principal diagnosis of HF are readmitted within 30 days in western countries [5, 6]. More recently, length of hospital stay has been suggested as another surrogate measure [7],

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✉ Takashi Kohno
kohno.a2@keio.jp

[1] Division of Cardiology, Department of Medicine, Keio University School of Medicine, 35 Shinanomachi, Shinjuku-ku, Tokyo 160-8582, Japan

[2] Division of Cardiology, Sakakibara Heart Institute, Tokyo, Japan

[3] Department of Cardiology, Kyorin University School of Medicine, Tokyo, Japan

[4] Department of Cardiology, St. Lukes International Hospital, Tokyo, Japan

and strong incentives have been introduced to reduce length of stay to maximize hospital profitability in the United States [8]. However, at the same time, a shorter length of stay could adversely affect the quality of health care, and the effect of shortening the length of stay on subsequent clinical outcomes has not been fully elucidated. Thus, despite the importance of early-phase readmissions, limited data are available regarding their relationship with length of hospital stay.

The objective of this study was to investigate the current status of length of hospital stay at Japanese urban tertiary care centers, its determining factors, and its impact on short-term HF readmission after discharge in patients with acute HF who were registered in a contemporary Japanese HF registry, West Tokyo Heart Failure (WET-HF) database.

## Methods

### Study design

We analyzed data of 2896 consecutive patients with acute HF registered in the WET-HF registry between January 2006 and June 2015. Details of the WET-HF registry have been described previously [9, 10]. Briefly, this database is an ongoing, prospective, multicenter registry designed to collect the clinical background and outcome data of patients with acute HF. On the basis of the Framingham criteria, acute HF was defined as rapid-onset HF or a change in the signs and symptoms of HF that required urgent therapy and hospitalization [11]. Specifically, patients presenting with acute coronary syndrome were not included. The clinical diagnosis of acute HF was initially established by the treating cardiologists and was subsequently confirmed by at least one board-certified cardiologist at each institution. In addition, the site investigators were instructed to prospectively document the details of acute HF during the registration period. Before the launch of this registry, information regarding the objective of the present study, its social significance, and an abstract were provided for clinical trial registration in the University Hospital Medical Information Network (UMIN000001171). The WET-HF registry included two university hospitals and two tertiary referral hospitals within the metropolitan Tokyo area during this investigation, and participating hospitals were instructed to record and register data of consecutive hospital visits for acute HF. The present study was approved by each center's ethics review committee, and all patients provided informed consent before inclusion.

For each patient, the baseline data included: (1) age, sex, and body mass index; (2) causes of HF; (3) medical history; (4) vital signs; (5) physical examination; (6) laboratory data; (7) echocardiographic data; (8) length of stay; and (9) medication use. We calculated the Get with the Guidelines-Heart Failure (GWTG-HF) risk score, which is short-term prediction risk score, for each patient according to the statistical model described in the original article [12]. We previously reported that the GWTG-HF risk score can be applied to Japanese patients with acute HF to determine the risk of in-hospital mortality with good discrimination and calibration in this cohort [10]. The length of stay was defined as the difference between the date of the first day after discharge and admission date. Figure 1 shows the flowchart describing the study design. Patients whose length of stay information was unavailable ($n=1$) and those who experienced in-hospital death ($n=110$) were excluded. Finally, the remaining 2785 patients who discharged or transferred to the recuperation facilities were divided into 3 groups according to tertiles of length of stay: shorter length of stay ($\leq 12$ days, first tertile), intermediate length of stay (13–19 days, second tertile), and longer length of stay ($\geq 20$ days, third tertile), based on previous reports [13].

### Endpoint

The follow-up survey, using a chart or telephone review, was performed on 2629 patients with HF (94.4%). Information regarding the specific outcomes was obtained from the participating cardiologists and investigators, including: (1) 30-day readmission due to worsening HF; and (2) 30-day composite endpoint of cardiac death and readmission due to worsening HF. In addition, we obtained information regarding the 2-year outcome of cardiac death or readmission due to worsening HF. The treating physicians at each participating hospital made decisions regarding the readmission for HF according to the usual standard of care. In most cases,

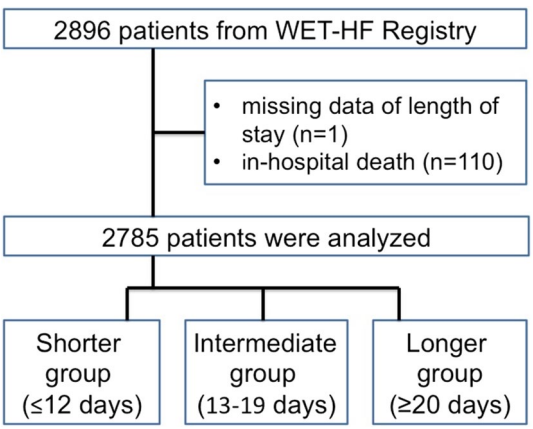


**Fig. 1** Flowchart describing the study design. A total of 2785 patients were divided into three groups according to the length of stay: shorter length of stay group ($\leq 12$ days, $n=1022$), intermediate length of stay group (13–19 days, $n=825$) and longer length of stay group ($\geq 20$ days, $n=938$). WET-HF, West Tokyo Heart Failure

patients were readmitted when clinical signs of decompensation, such as orthopnea or lower extremities edema, were present. Additionally, these events were adjudicated through chart abstractions performed by the site investigators.

### Statistical analysis

Normally distributed data were expressed as mean ± standard deviation, non-parametric data as median (interquartile range), and categorical data as percentages. Independent continuous variables were compared using analysis of variance, Student's *t* or Mann–Whitney's *U* tests, and categorical variables by Pearson's Chi square test. The multiple logistic regression model was used to analyze the determinants that influenced the length of hospital stay. For this analysis, only the admission characteristics and demographic data were included. In this model, adjustments were made using the clinically important variables, including age, sex, systolic blood pressure (BP), heart rate, medical history (diabetes mellitus, cerebral infarction, atrial fibrillation, chronic obstructive pulmonary disease and prior HF hospitalization), the levels of hemoglobin, blood urea nitrogen (BUN), sodium, brain natriuretic peptide (BNP), and the left ventricular ejection fraction (LVEF). Survival curves were calculated using Kaplan–Meier estimates, and were analyzed with the log-rank test. A multivariate Cox proportional hazard model was used to evaluate whether the length of stay was an independent predictor of short-term and long-term clinical outcomes after discharge. Models were adjusted for GWTG-HF risk score and past history of HF hospitalization. The results were reported as hazard ratios (HR), 95% confidence intervals (CI), and *p* values. HR values for outcomes in patients with shorter and longer length of hospital stay were compared with those of patients with intermediate length of stay. Multivariate analysis was also performed in the subgroup of patients with de novo HF or those with previous HF hospitalization. Furthermore, we developed the analysis among each sextile according to the length of stay: 1–9, 10–12, 13–15, 16–20, 21–28, and over 29 days, because of considering more details of association between length of stay and clinical outcomes. All statistical analyses were performed using SPSS version 22 (SPSS Inc., Chicago, IL, USA).

## Results

### Current status of length of hospital stay and its determining factors

Between 2006 and 2015, a total of 2785 patients with acute HF was registered. The mean age of patients was 73.8 ± 13.5 years, and 60.8% of them were men. Figure 2

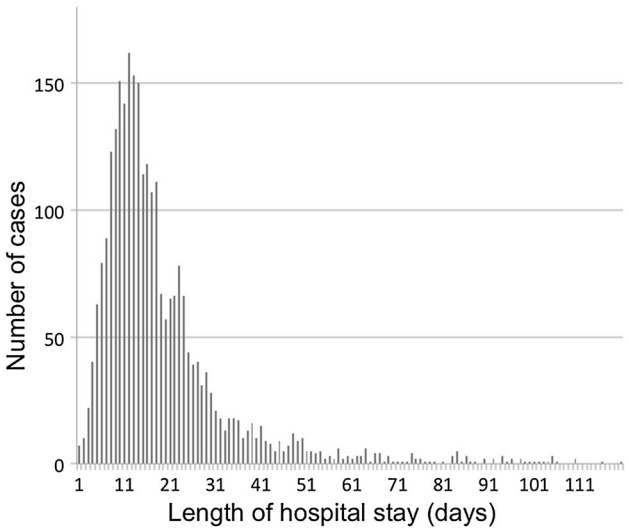


**Fig. 2** Distribution of the length of hospital stay

demonstrates the distribution of the length of stay in this cohort. The median length of stay was 15 days [interquartile range (IQR) 10–23 days], and 1022 patients (36.7%) had a hospital stay within the lower tertiles (1–12 days; shorter length of stay group), whereas 825 and 938 patients had intermediate (13–19 days) and longer (20 days or longer) length of hospital stay. The baseline characteristics of patients grouped according to their length of hospital stay are listed in Table 1. The medical management and clinical data at discharge for each of these groups are shown in Table 2.

Predictors for shorter or longer length of stay analyzed by multivariate logistic regression are shown in Table 3. Higher systolic BP, lower heart rate, prior HF hospitalization, higher sodium levels, and higher LVEF are independent predictors for shorter length of stay, after the adjustment for age, sex, vital signs, comorbidities, laboratory data, and LVEF. Conversely, lower systolic BP, higher heart rate, previous cerebral infarction, de novo HF hospitalization, lower hemoglobin levels, higher BUN levels, lower sodium levels, and decreased LVEF are independent predictors of longer length of stay. Age, sex, and BNP were not independently associated with the length of hospital stay.

### The effect of length of stay on short-term clinical outcomes after discharge

In our cohort, 114 patients (4.1%) were readmitted because of HF within 30 days after discharge, and 8 patients (0.3%) died from cardiac causes. We described the Kaplan–Meier curves of each endpoint until 30 days in patients with shorter, intermediate, and longer length of stay groups. Following index hospitalization, the event-free rate of HF

**Table 1** Baseline characteristics

| | Length of stay (days) | | | *p* value |
|---|---|---|---|---|
| | 1–12 ($n=1022$) | 13–19 ($n=825$) | ≥ 20 ($n=938$) | |
| Age (years) | 74.4 ± 12.9 | 73.3 ± 13.2 | 73.7 ± 14.3 | 0.226 |
| Female (%) | 39.8 | 37.8 | 39.8 | 0.621 |
| Body mass index (kg/m$^2$) | 23.4 ± 4.3 | 23.4 ± 4.3 | 23.3 ± 5.1 | 0.670 |
| Medical history | | | | |
| Hypertension (%) | 71.0 | 68.0 | 65.8 | 0.046 |
| Diabetes mellitus (%) | 36.1 | 35.0 | 35.3 | 0.874 |
| Dyslipidemia (%) | 41.6 | 38.1 | 36.7 | 0.073 |
| Smoking (%) | 44.0 | 46.3 | 39.6 | 0.017 |
| Atrial fibrillation (%) | 46.1 | 48.1 | 44.1 | 0.244 |
| Dialysis (%) | 6.1 | 2.2 | 2.9 | < 0.001 |
| Cerebral infarction (%) | 11.8 | 11.7 | 16.0 | 0.007 |
| COPD (%) | 4.2 | 5.2 | 6.7 | 0.053 |
| Prior HF hospitalization (%) | 32.5 | 30.1 | 29.6 | 0.327 |
| Cause of HF | | | | |
| Ischemic (%) | 28.2 | 27.2 | 29.7 | 0.476 |
| Valvular (%) | 24.0 | 26.2 | 25.1 | 0.559 |
| Dilated (%) | 12.0 | 14.5 | 16.4 | 0.021 |
| Clinical profile on admission | | | | |
| Systolic BP (mmHg) | 138 (120–162) | 137 (120–160) | 134 (113–156) | < 0.001 |
| Diastolic BP (mmHg) | 78 (65–94) | 80 (66–97) | 77 (64–90) | 0.010 |
| Heart rate (beats/min) | 88 (70–109) | 90 (74–109) | 92 (74–114) | < 0.001 |
| NYHA III or IV (%) | 79.6 | 80.3 | 86.8 | < 0.001 |
| PND (%) | 34.0 | 32.9 | 34.5 | 0.792 |
| Orthopnea (%) | 36.2 | 40.4 | 40.4 | 0.147 |
| JVD (%) | 37.5 | 46.1 | 46.8 | < 0.001 |
| Peripheral edema (%) | 60.8 | 68.6 | 65.8 | 0.002 |
| Cold extremities (%) | 19.4 | 17.7 | 25.5 | 0.001 |
| Rales (%) | 47.7 | 51.2 | 52.7 | 0.098 |
| S3 (%) | 30.3 | 39.3 | 42.0 | < 0.001 |
| Laboratory data on admission | | | | |
| Hemoglobin (g/dl) | 12.0 (10.5–13.5) | 12.1 (10.5–13.9) | 12.0 (10.1–13.8) | 0.215 |
| BUN (mg/dl) | 21.7 (16.0–30.7) | 20.6 (16.0–29.0) | 23.0 (17.4–34.2) | < 0.001 |
| Creatinine (mg/dl) | 1.0 (0.8–1.5) | 1.0 (0.8–1.4) | 1.2 (0.8–1.5) | < 0.001 |
| Sodium (mEq/L) | 140 (138–142) | 140 (138–142) | 139 (136–142) | < 0.001 |
| Potassium (mEq/L) | 4.3 (4.0–4.7) | 4.2 (3.9–4.6) | 4.3 (3.9–4.7) | 0.646 |
| BNP (pg/ml) | 499 (253–993) | 557 (302–1066) | 737 (385–1363) | 0.001 |

**Table 1** (continued)

| | Length of stay (days) | | | *p* value |
|---|---|---|---|---|
| | 1–12 ($n=1022$) | 13–19 ($n=825$) | ≥ 20 ($n=938$) | |
| CRP (mg/dl) | 0.4 (0.1–1.5) | 0.5 (0.2–1.6) | 0.8 (0.2–2.7) | < 0.001 |
| Echocardiographic parameters | | | | |
| LVDd (mm) | 51.0 (45.0–58.0) | 52.0 (45.0–59.0) | 53.0 (45.0–60.0) | 0.003 |
| LVDs (mm) | 38.0 (30.0–47.0) | 39.0 (31.9–49.0) | 39.0 (31.0–50.0) | 0.004 |
| LVEF (%) | 47.0 (35.0–60.0) | 45.0 (32.0–59.0) | 43.0 (30.0–58.0) | < 0.001 |
| LAD (mm) | 43.0 (39.0–48.0) | 45.0 (39.0–50.0) | 44.0 (38.0–50.0) | 0.002 |

Normally distributed data are expressed as mean ± standard deviation, non-parametric data as median (interquartile range), and categorical data as percentages

*COPD* chronic obstructive pulmonary disease, *HF* heart failure, *BP* blood pressure, *NYHA* New York Heart Association, *PND* paroxysmal nocturnal dyspnea, *JVD* jugular venous distension, *BUN* blood urea nitrogen, *BNP* brain natriuretic peptide, *CRP* C-reactive protein, *LVDd* left ventricular internal dimension in diastole, *LVDs* left ventricular internal dimension in systole, *LVEF* left ventricular ejection fraction, *LAD* left atrial dimension

readmission as well as composite endpoint of HF readmission and cardiac death in the shorter length of stay group was significantly higher than those in the intermediate length of stay group [log-rank test: $p=0.039$ and $p=0.037$, respectively (Fig. 3)]. Accordingly, in multivariate Cox analysis, shorter length of stay was associated with higher rate of 30-day HF readmission (HR 1.71, 95% CI 1.05–2.77) and composite endpoint (HR 1.66, 95% CI 1.04–2.65) after the adjustment for confounding factors (Table 4). In the longer length of stay group, both 30-day HF readmission and composite endpoint were not significantly different from that of the intermediate length of stay group, though they were considerably higher.

We also investigated the subgroup of patients with de novo HF hospitalization and those with previous HF admission, and 3.0% patients with de novo HF and 6.5% with those with previous HF admission were readmitted because of HF within 30 days after discharge. On univariate and multivariate Cox analyses, both shorter and longer length of stay in patients with de novo HF group tended to be associated with much higher prevalence of HF readmission and composite endpoint (Supplemental Table 1), while those in patients with previous HF admission group did not.

Subsequently, we divided the patients into 6 groups according to the length of hospital stay. Compared to the reference group (13–15 days), the adjusted rate of 30-day HF readmission was 2.2-fold higher in patients with shortest length of stay (1–9 days, HR 2.23, 95% CI 1.12–4.44, Fig. 4). A similar trend was seen in composite endpoint which was 2.3-fold higher (HR 2.31, 95% CI 1.16–4.58) than in patients of the reference group. In patients with longest group (over 29 days), adjusted rate of 30-day HF readmission and composite endpoint was considerably higher (HR 1.97, 95% CI 0.95–4.09, and HR 2.15, 95% CI 1.05–4.40).

We further investigated the long-term clinical outcomes after discharge in patients with shorter, intermediate, and longer length of stay groups. There were no differences of HF readmission and composite endpoints between each group, as shown through Kaplan–Meier curves and Cox analysis (Supplemental Fig. 1 and Table 4).

## The relationship between length of stay and GWTG-HF risk score

We analyzed the relationship between the length of hospital stay and GWTG-HF risk score. Overall, the GWTG-HF risk score (and prevalence of majority of its components) was significantly higher in the longer length of stay group (Table 5). However, 304 patients (10.9%) had lower tertile risk score and longer hospital stay, whereas 285 patients (10.2%) had higher tertile risk score and shorter hospital stay (Supplemental Fig. 2; Group I and A). Patient characteristics were compared between these two subgroups and their reference groups (low

**Table 2** Medical management and clinical data at discharge of patients with each length of stay group

| | Length of stay (days) | | | |
|---|---|---|---|---|
| | 1–12 ($n=1022$) | 13–19 ($n=825$) | ≥20 ($n=938$) | $p$ value |
| In-hospital intravenous therapy | | | | |
| Furosemide (%) | 55.4 | 66.7 | 74.7 | <0.001 |
| hANP (%) | 45.0 | 51.2 | 54.3 | <0.001 |
| Inotrope (%) | 5.1 | 8.2 | 22.5 | <0.001 |
| In-hospital management | | | | |
| NIPPV (%) | 17.2 | 15.1 | 23.3 | <0.001 |
| Intubation (%) | 2.4 | 3.3 | 9.1 | <0.001 |
| PCI (%) | 2.6 | 4.2 | 6.7 | <0.001 |
| CABG (%) | 0.5 | 0.2 | 4.8 | <0.001 |
| IABP (%) | 0.8 | 0.9 | 4.3 | <0.001 |
| PCPS (%) | 0.0 | 0.0 | 1.1 | <0.001 |
| CHDF (%) | 0.3 | 0.9 | 1.6 | 0.008 |
| Clinical profile and laboratory data at discharge | | | | |
| Systolic BP (mmHg) | 114 (103–128) | 110 (100–122) | 108 (97–121) | <0.001 |
| Diastolic BP (mmHg) | 60 (55–70) | 60 (56–68) | 60 (53–67) | 0.082 |
| Heart rate (beats/min) | 70 (60–80) | 70 (62–78) | 70 (62–80) | 0.244 |
| NYHA III or IV (%) | 21.4 | 22.7 | 30.4 | <0.001 |
| Hemoglobin (g/dl) | 12.1 (10.7–13.7) | 12.1 (10.8–14.0) | 11.4 (10.2–13.0) | <0.001 |
| BUN (mg/dl) | 23.0 (16.6–32.4) | 23.1 (17.0–32.0) | 22.7 (16.5–35.1) | 0.129 |
| Creatinine (mg/dl) | 1.0 (0.8–1.4) | 1.0 (0.8–1.4) | 1.0 (0.8–1.5) | 0.002 |
| Sodium (mEq/L) | 140 (137–141) | 139 (137–141) | 138 (136–140) | <0.001 |
| BNP (pg/ml) | 274 (126–604) | 273 (147–541) | 288 (147–629) | 0.015 |
| Medication at discharge | | | | |
| Loop diuretics (%) | 70.6 | 77.5 | 74.7 | 0.003 |
| ACEI or ARB (%) | 67.0 | 69.6 | 61.2 | 0.001 |
| MRA (%) | 33.9 | 39.4 | 36.5 | 0.053 |
| β-blockers (%) | 72.5 | 80.2 | 77.8 | <0.001 |
| Tolvaptan (%) | 2.5 | 2.3 | 4.5 | 0.018 |

Non-parametric data are expressed as median (interquartile range) and categorical data as percentages

*hANP* human atrial natriuretic peptide, *NIPPV* non-invasive positive pressure ventilation, *PCI* percutaneous coronary intervention, *CABG* coronary artery bypass graft, *IABP* intra-aortic balloon pumping, *PCPS* percutaneous cardio pulmonary support, *CHDF* continuous hemodiafiltration, *BP* blood pressure, *NYHA* New York Heart Association, *BUN* blood urea nitrogen, *BNP* brain natriuretic peptide, *ACEI* angiotensin-converting enzyme inhibitor, *ARB* angiotensin II receptor blocker, *MRA* mineral corticoid receptor antagonist

risk score and shorter hospital stay [Group G], and high-risk score and longer hospital stay group [Group C], respectively) to identify the factors that could potentially lead to the discrepancy between the length of stay and short-term prediction risk score. As a result, in patients with lower tertile risk score (Supplemental Fig. 2 ; Group G vs. I, and Supplemental Table 2), longer length of stay was associated with higher heart rate and BNP levels as well as lower sodium levels and LVEF. In patients with higher tertile risk score (Supplemental Fig. 2; Group A vs. C, and Supplemental Table 3), shorter length of stay was associated with lower BUN and BNP levels as well as higher sodium levels and LVEF.

## Discussion

In a contemporary Japanese multicenter acute HF registry, we analyzed 2785 patients who discharged or transferred to the recuperation facilities. Median length of hospital stay of the registered patients was 15 days, and 4.1% of patients were readmitted for HF within 30 days after discharge at urban tertiary care centers. Longer length of hospital stay was associated with established poor prognostic factors, such as lower systolic BP, higher heart rate, lower sodium, and decreased LVEF, whereas these factors were inversely associated with shorter length of hospital stay. Finally, the rate of 30-day HF readmission in the shorter length of stay

**Table 3** Determinants influencing the shorter or longer length of stay

| | Shorter length of stay | | | Longer length of stay | | |
|---|---|---|---|---|---|---|
| | *p* value | OR | 95% CI | *p* value | OR | 95% CI |
| Age (per each year increase) | 0.295 | 1.004 | 0.997–1.011 | 0.110 | 0.994 | 0.987–1.001 |
| Female | 0.910 | 0.989 | 0.824–1.188 | 0.465 | 0.931 | 0.769–1.128 |
| Systolic BP (per 10 mmHg increase) | 0.004 | 1.039 | 1.012–1.066 | 0.001 | 0.953 | 0.927–0.979 |
| Heart rate (per 10 beat/min increase) | 0.003 | 0.955 | 0.926–0.985 | < 0.001 | 1.057 | 1.025–1.091 |
| Diabetes mellitus | 0.695 | 1.036 | 0.867–1.239 | 0.519 | 0.941 | 0.781–1.133 |
| Cerebral infarction | 0.267 | 0.867 | 0.674–1.115 | 0.001 | 1.546 | 1.208–1.979 |
| Atrial fibrillation | 0.993 | 1.001 | 0.836–1.198 | 0.550 | 0.944 | 0.783–1.139 |
| COPD | 0.205 | 0.778 | 0.528–1.147 | 0.176 | 1.301 | 0.889–1.903 |
| Prior HF hospitalization | 0.010 | 1.279 | 1.061–1.542 | 0.031 | 0.804 | 0.659–0.980 |
| Hemoglobin (per each g/dl increase) | 0.145 | 1.032 | 0.989–1.077 | 0.028 | 0.952 | 0.912–0.995 |
| BUN (per 10 mg/dl increase) | 0.542 | 0.981 | 0.921–1.044 | 0.005 | 1.093 | 1.028–1.162 |
| Sodium (per each mEq/l increase) | 0.001 | 1.037 | 1.015–1.059 | < 0.001 | 0.948 | 0.928–0.968 |
| BNP (per 100 pg/ml increase) | 0.832 | 0.999 | 0.993–1.005 | 0.154 | 1.004 | 0.998–1.010 |
| LVEF (per 10 unit increase) | 0.002 | 1.099 | 1.035–1.167 | 0.008 | 0.918 | 0.862–0.978 |

Multiple logistic regression model was used, and adjusted for the following covariates: age, gender, systolic blood pressure, heart rate, medical history (diabetes mellitus, cerebral infarction, atrial fibrillation, chronic obstructive pulmonary disease, prior heart failure hospitalization), hemoglobin, blood urea nitrogen, sodium, brain natriuretic peptide, and left ventricular ejection fraction

*BP* blood pressure, *COPD* chronic obstructive pulmonary disease, *HF* heart failure, *BUN* blood urea nitrogen, *BNP* brain natriuretic peptide, *LVEF* left ventricular ejection fraction, *OR* odds ratio, *CI* confidence interval

group was significantly higher than those in the intermediate length of stay group, even after the vigorous risk adjustment.

We demonstrated that the acute HF patients successfully had low rate of 30-day HF readmission in our Japanese HF registry which had one of the longest mean length of hospital stays (21.0 days) among contemporary HF registries. Importantly, despite longer length of stay under the Japanese system, our study result indicates that relatively shorter length of stay was associated with higher rate of 30-day HF readmission. In recent years, 30-day readmission has been recognized as an important surrogate measure of hospital performance [2, 3, 13–16], the data regarding the association of the length of stay, another surrogate measure, with short-term readmission has been limited and inconsistent. Previous observational studies from United States revealed no significant association between short length of stay and 30-day readmission in patients with acute HF [15, 17]. On the other hand, shorter length of stay has been shown to be associated with higher rate of 30-day HF readmission in a large Canadian multicenter cohort [16]. In addition, within the Acute Study of Clinical Effectiveness of Nesiritide in Decompensated Heart Failure (ASCEND-HF), the mean country-level length of stay ranged between 4.9 and 14.6 days, and regional cohorts with mean length of stay < 10 days had higher prevalence of early readmission than those with longer length of stay [18]. Although there exist an incentive for patient care teams and hospitals to reduce length of hospital stay under modern healthcare system [19, 20], the results of these studies and ours indicate that optimal extension of hospital stay could improve discharge planning, initiate multidisciplinary interventions, ensure timely follow-up with outpatient providers, and coordinate care with ambulatory services [18]. A strategy to shorten length of hospital stay simply might be inappropriate as a future direction, and the simultaneous improvement of health policy supporting HF outpatients might be a prerequisite for the shortening of length of hospital stay. Organizational structure of the health system for timely access to acute and chronic HF care and management need to be established for HF outpatients. Furthermore, according to the data from the Acute Decompensated Heart Failure Syndromes (ATTEND) registry, a separate Japanese hospital-based prospective cohort study for acute HF, the frequency of sudden death was much higher during the first 14 days after admission than at any other time, with 71% of sudden deaths occurring during these periods [21], suggesting that we might also need to discuss the optimal length of hospital stay in terms of the risk of sudden death in the future.

Modern HF registry surveys have revealed regional differences in the length of hospital stay among patients admitted with acute HF. In the Acute Decompensated Heart Failure National Registry (ADHERE) and the Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients with Heart Failure (OPTIMIZE-HF) in the United States and the Euro Heart Failure Survey II (EHFS II) in Europe, the median length of stay was 4, 6, and 9 days, respectively

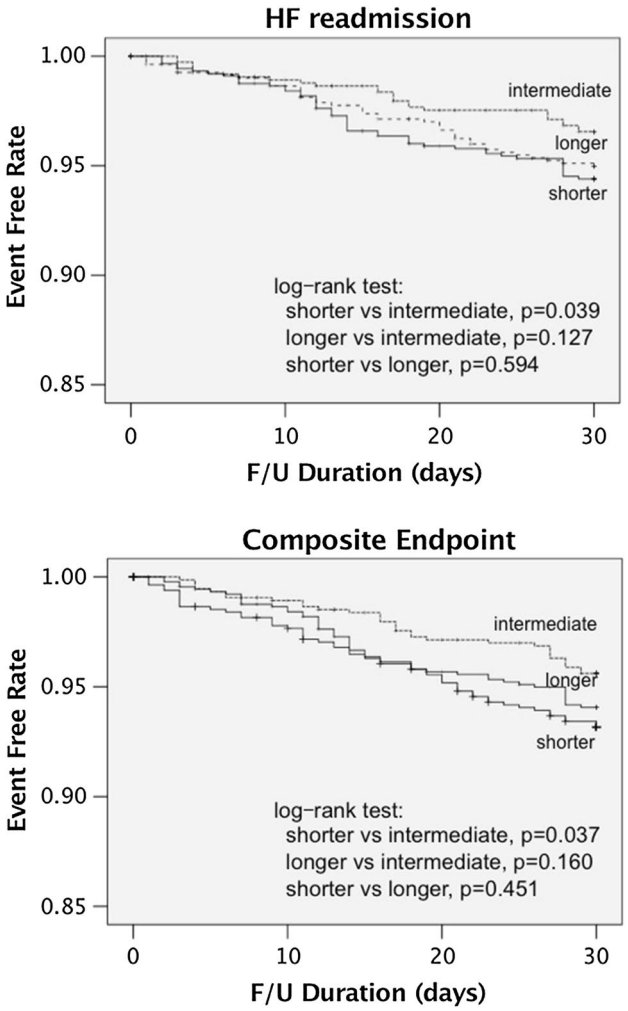


**Fig. 3** Kaplan–Meier survival curves for HF readmission and composite endpoint of HF readmission and cardiac death until 30 days after discharge in each group. HF, heart failure

[22–24]. However, in Japan, ATTEND and Japanese Cardiac Registry of Heart Failure in Cardiology (JCARE-CARD) registries, the reported median length of stay was 21 and 15 days [25, 26], respectively, which is consistent with the findings of our registry. The reason for the relatively longer hospital length of stay in acute HF patients in Japan is probably multifactorial. The local medical practices and health system operation could be reasons behind this variation [1, 2, 25, 27]. Under the universal health coverage system, which ensures that the entire population receives the same level and quality of medical services [28], the evaluation of etiology and severity of HF, and the adjustment of optimal medication are often performed during index hospitalization in Japan. Admission to discharge % BNP reduction was lower in Western HF cohorts (26–43%) with that of our Japanese cohort (54%) [29–31], suggesting that longer length of stay could be associated with optimal decongestion at discharge. Additionally, hospitalized patients with HF often spent enough time to participate in in-patient disease management programs, including patient education, dietary consultations, and exercise programs, to overcome socioeconomic barriers. This unique health system could explain the longer length of stay in admitted patients with HF in Japan, which could contribute to quite low early readmission rate. At the same time, the number of HF patients is rapidly increasing and is exacerbated by a uniquely long duration of life expectancy in Japan; [32, 33] the prolonged length of hospital stay in these patients is becoming an urgent issue, and further investigation is necessary to seek the ideal balance of cost-efficacy within this area of research.

Data regarding the determinants of the length of stay in patients with acute HF are limited [17, 26, 34, 35]. In this study, we demonstrated that several poor prognostic markers, such as low systolic BP, high heart rate, low sodium levels, and high BUN levels, which are components of GWTG-HF risk score, were independent determinants of longer length of hospital stay, suggesting that longer length of stay could reflect more severe HF conditions in our cohort. On the other hand, there were some patients with discrepancies between the length of hospital stay and their GWTG-HF risk score, suggesting that risk stratification for length of stay based on the risk model for in-hospital death could be limited. Concordant with this finding, the data from 3 large-scale quality acute HF registries including ours revealed that the association between length of hospital stay and in-hospital mortality was less significant after adjusting for baseline patient risk [36]. According to previous reports, there could be several other possible key factors related to the length of hospital stay. For instance, social problems could be related to longer length of stay, because interventions such as a need for help at home or other home-based interventions could be required [37]. Psychiatric comorbidities and non-adherence were also related to the length of stay [38, 39]. In a future study, a comprehensive evaluation including socioeconomic status, residential and hospital environment, and self-care behavior should be performed to establish a precise prediction model for the length of stay.

Our study has several limitations. First, the patients' condition at the time of discharge was not the same in all cases. The criteria of discharge depended on the judgment of treating clinicians. Second, this study could not evaluate several important factors after discharge, such as the post-discharge patients' dispositions as well as the management. Especially, there were some patients transferred to recuperation hospitals or facilities, whose length of hospital stay generally tends to be longer. In fact, within the separate analysis from the core hospital center of WET-HF (Keio University), roughly 15% of the HF patients were discharged in recuperation hospitals or facilities, and majority of these patients were classified in longer length of stay group (data

**Table 4** Cox proportional hazard model of each endpoint until 30 days and 2 years

| | Unadjusted | | | Adjusted | | |
|---|---|---|---|---|---|---|
| | *p* value | HR | 95% CI | *p* value | HR | 95% CI |
| HF readmission (30 days) | | | | | | |
| Shorter length of stay | 0.02 | 1.76 | 1.09–2.86 | 0.03 | 1.71 | 1.05–2.77 |
| Intermediate length of stay | Reference | | | | | |
| Longer length of stay | 0.06 | 1.63 | 0.98–2.71 | 0.07 | 1.59 | 0.96–2.65 |
| Composite endpoint (30 days) | | | | | | |
| Shorter length of stay | 0.03 | 1.70 | 1.07–2.71 | 0.03 | 1.66 | 1.04–2.65 |
| Intermediate length of stay | Reference | | | | | |
| Longer length of stay | 0.05 | 1.63 | 1.00–2.67 | 0.08 | 1.56 | 0.95–2.54 |
| HF readmission (2 years) | | | | | | |
| Shorter length of stay | 0.52 | 1.06 | 0.89–1.27 | 0.74 | 1.03 | 0.86–1.24 |
| Intermediate length of stay | Reference | | | | | |
| Longer length of stay | 0.45 | 1.08 | 0.89–1.30 | 0.83 | 0.98 | 0.81–1.19 |
| Composite endpoint (2 years) | | | | | | |
| Shorter length of stay | 0.57 | 1.05 | 0.89–1.25 | 0.78 | 1.02 | 0.86–1.22 |
| Intermediate length of stay | Reference | | | | | |
| Longer length of stay | 0.24 | 1.11 | 0.93–1.34 | 0.99 | 1.00 | 0.83–1.20 |

Models were adjusted for the Get with the Guidelines-Heart Failure risk score and past history of HF admission

*HR* hazard ratio, *CI* confidence interval, *HF* heart failure

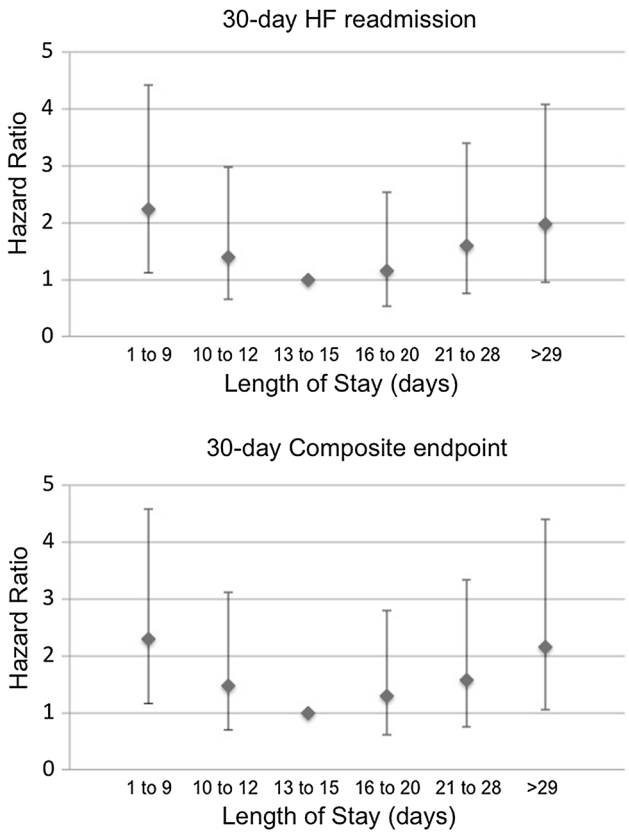


**Fig. 4** Cox proportional hazard model of 30-day HF readmission and composite endpoint in 6 groups. Models were adjusted for the Get with the Guidelines-Heart Failure risk score and past history of HF admission. HF, heart failure

not shown). These patients could reinitiate the treatment after reexacerbation of HF in the recuperation hospitals or be applied to different criteria for rehospitalization in the tertiary care center. Third, the impact of length of stay on short-term readmission was not fully evaluated in various subpopulations of HF. Interestingly, unfavorable effect of shorter length of stay tended to be only observed in de novo HF patients in our study cohort, suggesting that not every patient might need prolonged hospital stay. To identify the patients in whom prolongation of HF hospitalization might be effective, further studies including larger study population for more detailed subanalyses will be needed in the future. Fourth, the registries consist of 4 institutions (two university hospitals and two tertiary referral hospitals) within the metropolitan area during this investigation, and the results may not be generalized to other area or other type of hospitals even in Japan. Future studies including patients in other regions (e.g. rural area) and other type of hospitals (e.g. non-tertiary hospitals or nonacademic hospitals) will be needed to confirm our conclusion, because variation in patient characteristic, treatment, and practice pattern may exist. Fifth, the mechanism why shorter length of stay was associated with short-term prognosis, but not with long-term prognosis remains unknown. One of hypothesis is that the shorter length of hospital stay could be associated with insufficient decongestion at discharge and may have led to worse short-term prognosis. Although plasma BNP levels at discharge did not differ by length of stay in our cohort, comprehensive pre-discharge evaluation on congestion will be

**Table 5** GWTG-HF risk score in patients with each length of stay group

| | Length of stay (days) | | | *p* value |
|---|---|---|---|---|
| | 1–12 ($n=1022$) | 13–19 ($n=825$) | ≥ 20 ($n=938$) | |
| Total points, points | 39.5 ± 7.4 | 39.6 ± 7.7 | 41.6 ± 8.5 | < 0.001 |
| Each components, points | | | | |
| Systolic BP | 11.6 ± 6.0 | 11.9 ± 5.7 | 12.6 ± 6.0 | < 0.001 |
| BUN | 4.1 ± 2.7 | 3.9 ± 2.5 | 4.6 ± 3.3 | < 0.001 |
| Sodium | 0.6 ± 1.0 | 0.6 ± 1.0 | 0.9 ± 1.2 | < 0.001 |
| Age | 16.6 ± 3.6 | 16.4 ± 3.7 | 16.4 ± 3.9 | 0.326 |
| Heart rate | 3.5 ± 3.4 | 3.8 ± 3.3 | 4.0 ± 3.4 | 0.004 |
| Black race | 3 | 3 | 3 | - |
| COPD | 0.04 ± 0.20 | 0.05 ± 0.22 | 0.07 ± 0.25 | 0.053 |

Values are expressed as mean ± SD

*GWTG-HF* Get with the Guidelines-Heart Failure, *BP* blood pressure, *BUN* blood urea nitrogen, *COPD* chronic obstructive pulmonary disease

needed to examine this hypothesis [40]. Another hypothesis is that shorter length of stay might be associated with less comprehensive, multidisciplinary transitional care management, which might be susceptible to early readmission, as discussed in other paper [16]. To elucidate the mechanism, further studies evaluating details of management status including multidisciplinary team management at discharge will be needed in the future.

In conclusion, the Japanese acute HF patients successfully had low rate of early HF readmission after a long length of hospital stay. Short length of stay was associated with increased rates of 30-day HF readmission. Cautious discussion about shortening the length of hospital stay in patients with acute HF is necessary to establish an ideal therapeutic approach.

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## Compliance with ethical standards

**Conflict of interest** All the authors declare that they have no conflict of interest.

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