Characteristics of Elderly Patients with Heart Failure and Impact on Activities of Daily Living: A Registry Report from Super-Aged Society

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ABSTRACT

Background: To assess the health care burden of elderly patients with heart failure (HF) in an aging Japanese community-based hospital, we investigated the outcomes of cardiac rehabilitation.
Methods and Results: We enrolled all patients with HF aged ≥65 years admitted to 3 hospitals in the Niigata Prefecture. We prospectively collected data on their hospital stays and for 2 years postdischarge. The cohort comprised 617 patients (46.5% men; mean age 84.7 years), 76.2% of whom were aged ≥80 years. Among these patients, 15.6% were nursing home residents, 57.7% required long-term care insurance, only 37.6% could walk unaided at the time of admission, and 70.5% required cardiac rehabilitation; age had no significant rehabilitative effect on the degree of improvement in activities of daily living (ADLs). Two years postdischarge, all-cause mortality, and HF rehospitalization were 41.1% and 38.6%, respectively. The ADL score at discharge was an independent prognostic factor for mortality. The incidence of mortality and rehospitalization was lower in elderly patients with preserved ADLs at discharge.
Conclusions: Elderly patients with HF in our super-aged society were mainly octogenarians who required disease management and personalized care support. Although their ADL scores increased with comprehensive cardiac rehabilitation, improved scores at discharge were closely associated with prognosis. (*J Cardiac Fail 2021;27:1203−1213*)
Key Words: Super-aged society, heart failure, octogenarians, cardiac rehabilitation.

Japan has the world's most rapidly aging population. Both the World Health Organization and the United Nations define a society with 7% or more of its population aged ≥65 years as an "aging society," 14% or more as an "elderly society," and 21% or more as a "super-aged society."[1] Since 2000, the proportion of older people aged ≥65 years has been the highest worldwide, and in 2007, Japan became a super-aged society. It is further projected to reach 40% by 2060. Additionally, the shrinking of the working-age population, which supports the rising number of older people, also poses a problem.[2] As Japan faces this issue, the number of patients with heart failure (HF), particularly the elderly, also increases.[3,4]

Conventionally, most patients receiving treatment for HF have had reduced cardiac function. These patients require sophisticated surgical interventions and medical devices available only in hospitals capable of providing standardized options using intensive care units and specialist teams. Patients with HF with preserved ejection fraction are mostly older,[4,5] and they often receive medical care in community-based hospitals. As advancing age accelerates frailty, many elderly patients with HF require physical and social care in addition to disease management. Many clinicians are experiencing the weight of the medical burden associated with the declining activities of daily living (ADLs) of hospitalized elderly patients with HF. However, the relevant clinical characteristics, prognoses and causes of this burden remain unclear.

Comprehensive cardiac rehabilitation programs have been shown to improve the prognosis of patients with HF,[6−8]

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although their efficacy for "very elderly" individuals and their impact on improving ADLs are unknown. Thus, we conducted a registry study to clarify the effect of cardiac REHAbilitation with multidisciplinary intervention for Chronic Heart Failure of ELDerly patients (J-REHACHF-ELD study) in a super-aged society and ascertain the real figure of HF in elderly patients and efficacy of rehabilitation measures. We investigated the clinical and social characteristics of elderly patients with HF admitted in community-based hospitals (the effectiveness of in-hospital management, including comprehensive rehabilitation), their prognoses and related factors.

Methods

Study Cohort

This study was conducted in 3 community-based hospitals in the Niigata Prefecture, 2 in Niigata City (Shinrakuen Hospital and Niigata Minami Hospital) and 1 in Sado City (Sado General Hospital). All patients aged ≥65 years admitted for HF in the above hospitals between January 2017 and March 2018 were enrolled. Medical data pertaining to hospital stay were collected prospectively. The patient data 2 years after discharge were obtained from each hospital.

The demographic and hospital backgrounds of our study region in 2017 were obtained following the period of the registry's initiation. Niigata City is the prefectural capital of Niigata Prefecture. Its population at that time consisted of 804,152 people, of whom 28.4% were aged ≥65 years and 9.1% ≥80 years; these percentages were slightly higher than the overall Japanese rates of 27.8% and 8.5%, respectively. Sado, a city neighboring Niigata, is an island with a population of 55,211 people, of whom 41.3% were aged ≥65 years and 17.2% ≥80 years. The 3 study sites are super-aged societies based on the World Health Organization/United Nations criteria[1] and are highlighted as the most super-aging cities worldwide. Niigata City has 6 cardiovascular centers and 19 primary and secondary referral medical centers. Of the participating hospitals, the Shinrakuen Hospital functions as a cardiovascular center but without undertaking emergency cardiovascular surgeries. The Niigata Minami Hospital is a typical community-based hospital without cardiac catheterization facilities, accepting emergency patients up to moderate illness and transferring patients in the recovery phase from the neighboring cardiovascular center. Sado General Hospital functions as a cardiovascular center and a referral medical center but does not perform emergency cardiovascular surgery.

Diagnosis and Therapeutic Interventions

To document clinical practice, we registered the diagnosis of HF as "heart failure," the disease name in the Diagnosis Procedure Combination (DPC) system on admission. The DPC system has been designated by the Japanese government for estimating the insurance charge for inpatient treatment, in which the disease names are classified according to the International Classification of Diseases-10.[9] Heart diseases and other comorbidities were identified by health insurance codes and/or the DPC disease name. The level of care needs was classified according to the levels of the Japanese long-term care insurance system. There are 7 levels based on physical and mental conditions: support level 1−2 and care level 1−5.[10] In Japan, in response to the aging of the population, which exceeded 14% in the 1990s, a long-term care insurance system was established in 2000 to provide long-term care to all Japanese people aged ≥65 years.

Because this was an observational study, decisions about therapeutic interventions were left to the discretion of the investigators. Cardiologists were affiliated with all 3 hospitals that were designated as institutes for cardiac rehabilitation. The rehabilitation was conducted according to the cardiac rehabilitation guidelines.[11]

Ethical Consideration

Prior to the study's initiation, the institutional review boards of Tokyo Medical and Dental University (M2016-169) and the other participating institutions approved this study. All the enrolled patients were informed that they could refuse the use of their data. Because the study protocol was based on the extraction and review of medical records in an anonymous fashion, the institutional review board waived the requirement for patient consent.

Statistical Analysis

We divided the population into an elderly group (aged 65−79 years) and a very elderly group (aged ≥80 years) to account for the progressive aging of the Japanese population. For these groups, we conducted a comparative analysis of clinical and social backgrounds, as well as treatment outcomes, including rehabilitation. Continuous variables were expressed as mean ± standard deviation or median (interquartile range). Categorical variables were presented as numbers and percentages. Continuous variables were compared using the Student *t* test or the Mann-Whitney U test based on the distribution. The Wilcoxon rank-sum test was used to identify the improvement in the Barthel Index (BI) of ADLs. Categorical variables were compared using the χ^2 test when appropriate; otherwise, the Fisher exact test was used. The Jonckheere-Terpstra trend test was used to compare trends in BI between differing age groups. Comparison of improvements in the BI in each age group was made using a 1-way analysis of variance. Survival curves were plotted using the Kaplan-Meier method and compared using the log-rank test. For cumulative occurrence of rehospitalization, the Gray test was performed to analyze mortality events as competing risks. Cox proportional hazards models were used to evaluate the risk of time-dependent variables. Postdischarge event rates were described as the number of events per patient-years. Statistical analysis was performed using SPSS, version 23.0 (SPSS, Chicago, IL, USA) and EZR, version 1.42 (Saitama Medical Center, Jichi Medical

University, Saitama, Japan). Two-sided P values <0.05 were considered significant.

Results

Patient Characteristics

Altogether, 624 patients were enrolled, and excluding patients with incomplete data acquisition, the final cohort included 617 patients. Table 1 shows the patients' clinical characteristics. The overall mean age was 84.7 years; a large proportion of those aged ≥80 years were women, and 76.2% were aged ≥80 years (Fig. 1). There was no significant difference in this trend in the 3 facilities.

We compared the "very elderly" group (patient profile of the main patient population aged ≥80 years) with the "elderly" group (patient profile of the main patient population aged 65−79 years). Many of the very elderly patients were underweight with a body mass index (BMI) of <18.5 kg/m^2. The most common underlying causes of HF were ischemia and valvular heart disease, whereas cardiomyopathy was rare in the very elderly patients. Atrial fibrillation was diagnosed in 53.8% of all patients. Regarding comorbidities, metabolic diseases such as dyslipidemia and diabetes mellitus were less common in the very elderly, whereas cognitive disorders and skeletal diseases were more common. Among the very elderly, 56.2% suffered from 3 or more major comorbidities. Regarding social and lifestyle factors, before hospitalization, 15.6% of patients resided in nursing homes, 22.1% lived alone in their own homes, and 33.8% lived with another person (21.7% with their spouses). Most participants in the very elderly group were nursing-home residents, and only a few lived alone or with their spouses compared to those in the elderly group. During hospitalization, 57.7% of all patients required long-term care insurance, and this rate increased to 66.8% in the very elderly.

Blood hematological and biochemistry tests at admission showed that the incidence of anemia was high, at 69.3% overall, 59.7% in the elderly, and 72.3% in the very elderly ($P = 0.004$). The incidence of hypoalbuminemia (albumin <3.4 g/dL) was 40.9% overall, 33.3% in the elderly, and 43.1% in the very elderly ($P = 0.063$). The incidence of renal impairment (estimated glomerular filtration rate <60 mL/min/1.73 m^2) was 77.8% overall, 70.4% in the elderly, and 80.0% in the very elderly ($P = 0.016$) and that of hyponatremia (Na <136 mmol/L) was 18.3% overall, 16.2% in the elderly, and 19.0% in the very elderly ($P = 0.449$). Nutritional status evaluated by the geriatric nutritional risk index (GNRI) was moderately impaired (<92) or worse in 44.1% of all patients, 31.6% in the elderly and 47.8% in the very elderly ($P = 0.002$).

ADLs were assessed according to the BI. The median score on admission was low at 65 (IQR 5−100) among elderly and even lower at 15 (IQR 0−60) among the very elderly. The proportions of patients capable of walking and using the toilet independently were small for the very elderly, at 32.1% and 22.8%, respectively. Rehabilitation was provided for 70.5% of patients, and a mean of 17.4 hours was the required time consumed over a median of 17 days. One unit meant 20 minutes of rehabilitation implementation, and the average daily rehabilitation time per person was 2.2 ± 1.6 units (44.1 ± 32.1 minutes) for the elderly and 1.8±1.4 units (36.9±28.8 minutes) for the very elderly. Age made no significant difference in the median length of hospital stay, which was 21 days. However, the competing risk due to death should be considered because death during hospitalization is more common in the very elderly group. Upon analyzing surviving cases only, the very elderly group had significantly longer hospital stays. In addition, 33.7% of patients had to stay for more than 30 days. The in-hospital death rate was 16.9%, with the majority of mortalities occurring in the very elderly.

Clinical Presentation of HF

Table 2 shows the clinical parameters related to HF on admission. Chest radiographs at admission revealed pulmonary congestion in 67.6% and pleural effusion in 71.3% of patients. B-type natriuretic peptide (BNP) and N-terminal pro-B-type natriuretic peptide (NT-proBNP) levels were moderately to severely elevated. Regarding clinical scenario (CS) categories estimated from blood pressure values at admission,[12] most patients were CS1 or CS2, with fewer than 10% being CS3 with deteriorating hemodynamics. Among those who underwent echocardiography, both the left atrial and left ventricular diameters were enlarged, although the ejection fraction was preserved in most of those in both age groups and in 57.9% of all patients. Concerning the valvular function, the rate of aortic stenosis was notably elevated in very elderly patients.

Clinical Outcomes of Survivors at Discharge

Table 3 shows the clinical outcomes of survivors at discharge: 17.3% of patients were obligated to transfer to terminal institutes; the proportion of patients discharged to their own homes were 79.3% overall, 86.5% in the elderly, and 76.6% in the very elderly. ADLs scores on discharge were higher than those on admission; however, for the very elderly, the proportions of patients capable of walking or using the toilet unaided were 64.8% and 50.0%, respectively. These figures were lower than those for the elderly. Regarding medication prescriptions upon discharge, the fewest included, in the very elderly group, angiotensin-converting enzyme inhibitors or angiotensin receptor blockers, beta-blockers or direct oral anticoagulants, and the more benzodiazepines.

Effect of Hospital Treatment, Including Rehabilitation, on ADLs Scores

To examine factors associated with reduced ADLs on admission, we analyzed single correlations of BI on admission with other factors on admission (age, BMI, hemoglobin, estimated glomerular filtration rate, ejection fraction on

Table 1. Patient Characteristics

	All patients N=617		Elderly group (65-79 years old) N=147		Very elderly group (≥80 years old) N=470		
	Total data		Total data		Total data		*p-value*
Age, yrs	617	84.7 ± 8.1	147	73.3 ± 4.1	470	88.3 ± 5.1	<0.001
Male		287 (46.5)		89 (60.5)		198 (42.1)	<0.001
BMI, kg/m^2	609	22.1 ± 4.2	147	23.2 ± 4.9	462	21.7 ± 3.9	<0.001
Underweight (<18.5)		116 (19.0)		21 (14.3)		95 (20.6)	0.008
Obese (≥25)		126 (20.7)		43 (29.3)		83 (18.0)	
Underlying Cardiac disease	617		147		470		
Ishemic		207 (33.5)		54 (36.7)		153 (32.6)	0.349
Valvular heart disease		189 (30.6)		35 (23.8)		154 (32.8)	0.040
Cardiomyopathy		52 (8.4)		24 (16.3)		28 (6.0)	<0.001
Atrial fibrillation		332 (53.8)		80 (54.4)		252 (53.6)	0.864
Comorbidities	617		147		470		
Hypertension		471 (76.3)		114 (77.6)		357 (76.0)	0.692
Dyslipidemia		193 (31.3)		57 (38.8)		136 (28.9)	0.025
Diabetes mellitus		213 (34.5)		68 (46.3)		145 (30.9)	0.001
Hyperuricemia		134 (21.7)		37 (25.2)		97 (20.6)	0.245
Cognitive disorder		141 (22.9)		12 (8.2)		129 (27.4)	<0.001
CKD		172 (27.9)		50 (34.0)		122 (26.0)	0.057
Chronic respiratory disease		189 (30.6)		39 (26.5)		150 (31.9)	0.216
Cancer		64 (10.4)		18 (12.2)		46 (9.8)	0.394
Neurological disease		174 (28.2)		37 (25.2)		137 (29.1)	0.349
Stroke		154 (25.0)		31 (21.1)		123 (26.2)	0.214
Skeletal disease		185 (30.0)		32 (21.8)		153 (32.6)	0.013
Number of major comorbidities[a]	603	2.6 ± 1.2	142	2.1 ± 1.2	461	2.7 ± 1.2	<0.001
None		21 (3.5)		12 (8.5)		9 (2.0)	
1-2		272 (45.1)		79 (55.6)		193 (41.9)	<0.001
≥3		310 (51.4)		51 (35.9)		259 (56.2)	
Residence before admission	617		147		470		
Own home		479 (77.6)		124 (84.4)		355 (75.5)	
Nursing home		96 (15.6)		10 (6.8)		86 (18.3)	0.003
Hospital (patient transfer)		42 (6.8)		13 (8.8)		29 (6.2)	
Household composition	479		124		355		
Alone		106 (22.1)		35 (28.2)		71 (20.0)	0.057
With family		373 (77.9)		89 (71.8)		284 (80.0)	0.057
Co-resident family members		2 [1-3]		1 [1-3]		2 [1-3]	0.196
One other family member		162 (33.8)		46 (37.1)		116 (32.7)	0.072
Long-term care insurance	617		147		470		
None		261 (42.3)		105 (71.4)		156 (33.2)	
Use of long-term care insurance		356 (57.7)		42 (28.6)		314 (66.8)	<0.001
Support level 1-2, Care level 1-2		225 (36.5)		27 (18.4)		198 (42.1)	
Care level 3-5		131 (21.2)		15 (10.2)		116 (24.7)	
Blood chemical analysis on admission							
Hb, g/dL	609	11.2 ± 2.3	144	11.8 ± 2.5	465	11.0 ± 2.2	<0.001
Alb, g/dL	504	3.4 ± 0.6	114	3.6 ± 0.6	390	3.4 ± 0.6	0.001
UA, mg/dL	433	6.8 ± 2.4	115	6.4 ± 1.9	318	6.9 ± 2.5	0.040
eGFR, mL/min/1.73m^2	603	42.9 ± 23.2	142	48.7 ± 27.5	461	41.1 ± 21.5	0.001
Na, mmol/L	605	139.3 ± 5.4	142	139.5 ± 5.0	463	139.2 ± 5.5	0.625
HbA1c, %	316	6.2 ± 1.0	83	6.4 ± 1.3	233	6.1 ± 0.9	0.019
Nutritional status on admission							
GNRI	497	92.8 ± 12.4	114	96.7 ± 13.1	383	91.6 ± 11.9	<0.001
ADL score (BI) on admission	617	25 [0-80]	147	65 [5-100]	470	15 [0-60]	<0.001
Mobility score ≥10		232 (37.6)		81 (55.1)		151 (32.1)	<0.001
Toilet use score=10		181 (29.3)		74 (50.3)		107 (22.8)	<0.001
Implementation of rehabilitation	617	435 (70.5)	147	94 (63.9)	470	341 (72.6)	0.046
Number of days		17 [9-40]		15 [8.8-29.3]		17 [9-42]	0.318
Rehabilitation units (1unit=20min)		52.1 ± 64.4		54.0 ± 65.3		51.6 ± 64.3	0.752
Length of hospital stay, days	617	21 [13-41]	147	19 [12-31]	470	22 [13-43.3]	0.056
≥30 days		209 (33.9)		40 (27.2)		169 (36.0)	0.051
Surviving patients only, days	513	21 [14-38]	141	19 [12-30.5]	372	23 [14-43]	0.012
≥30 days		173 (33.7)		38 (27.0)		135 (36.3)	0.046
In-hospital death	617	104 (16.9)	147	6 (4.1)	470	98 (20.9)	<0.001

Variables are expressed as mean ± SD, median [interquartile range], or numbers (%).

[a]Diseases that affect exercise tolerance and ADL, such as respiratory disease, skeletal disease, neurological disease, cognitive disorder, anemia, and CKD, are counted as major comorbidities.ADLs, activities of daily living; Alb, albumin; BI, Barthel index; BMI, body mass index; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; GNRI, geriatric nutritional risk index; Hb, hemoglobin; HbA1c, glycosylated hemoglobin; Na, sodium, UA, urinalysis.

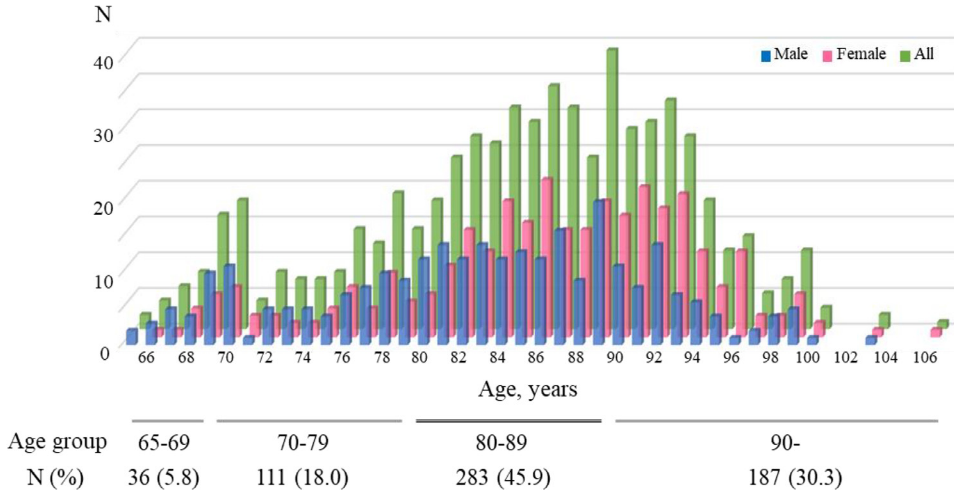

Fig. 1. Age distribution of the patients. The distribution of elderly patients with heart failure admitted to community-based hospitals peaked in the 80−89 age group for both men and women.

echocardiogram, cardiothoracic ratio (CTR) on chest radiograph, severity of BNP, GNRI, and level of care (the level of care was statistically processed in 8 levels, with 0 standing for unapplied, 1−2 for support 1−2, and 3−8 for care 1−5). The correlation coefficient r was more than 0.2 for age ($r = -0.33$, $P < 0.01$), hemoglobin level at admission ($r = 0.21$, $P < 0.01$), level of care at admission ($r = 0.45$, $P < 0.01$), and GNRI at admission ($r = 0.30$, $P < 0.001$). The results did not correlate with factors related to HF such as EF, CTR and BNP.

Of the surviving patients, 388 were rehabilitated, and BI improved from 35 (IQR 0−85) to 75 (IQR 40−100) ($P < 0.01$). Ninety-four patients in the elderly group improved from 70 (IQR 8.75−100) to 100 (IQR 68.75−100) ($P < 0.01$), and 294 patients in the very elderly group improved from 27.5 (IQR 0-70) to 65 (IQR 30-100 ($P < 0.01$). The degree of improvement (ΔBI) was 20.1 ± 36.4 and 24.2 ± 36.8, respectively, with no significant difference ($P = 0.345$). When the improvement in BI was analyzed by age group (Fig. 2), BI was significantly improved by disease management, including rehabilitation, even when evaluated for each age group. There was no significant difference between the age groups regarding the degree of practical improvement (ΔBI). In addition, ΔBI changed by approximately 20. However, older patients were less likely to achieve such an improvement, and trend analysis revealed that the ADL scores on both admission and discharge declined significantly with advanced age.

Analysis of Prognosis

During the 2-year observation period after discharge, all-cause mortality was high at 23.3% for 12 months and 41.1% for 24 months, and likewise with rehospitalization for HF at 30.8% for 12 months and 38.6% for 24 months. The event-free rate for all-cause death and hospitalization was extremely low at 20.8% (Fig. 3A). An investigation of causes of death during this period revealed that the most common cause was HF (60 cases; 35.3%), followed by respiratory disease (24 cases; 14.1%) and senile deterioration (18 cases; 10.6%), and the cause was unknown in 17 cases (10.0%).

When comparing the occurrence of all-cause mortality rate in the elderly and very elderly groups (Fig. 3B), we found a difference in the occurrence of events at 2 years between the elderly and very elderly groups (31.2% and 45.3%, respectively) ($P = 0.012$). However, there was no difference in the occurrence of hospitalizations for any-cause or HF when mortality events were analyzed as competing risks.

A comparison of mortality rates among patients with different levels of ADL scores on discharge (Fig. 3C) showed that mortality was 27.9% among patients with BI ≥85, 49.1% among those with BI 40−80, and 67.5% among those with BI <40; the risk of death increased as BI declined. Analyzing the occurrence of fatal events after discharge for each degree of improvement in ADL score during hospitalization (ΔBI) (Fig. 3D), we found that patients with improved BI had better prognoses. There is a significant correlation between BI at discharge and ΔBI ($r = 0.366$, $P < 0.001$).

Cox regression analysis (Table 4) showed that a low BI on discharge was an independent risk factor for death in analyses incorporating both the severity of HF on admission (Models 2 and 3) and general prognostic factors for HF (Model 3). We carried out a Kaplan-Meier survival analysis of the time to the first HF rehospitalization, although no significant trend based on the BI level on discharge was identified.

During the 2-year follow-up period, we analyzed the occurrence of events and evaluated the incidence of events per patient-year for each BI level (Table 5). Although statistical tests were not performed due to the sample size, both all-cause and cardiovascular mortalities were lower in patients

Table 2. Clinical Characteristics of Heart Failure

	All patients N=617		Elderly group (65-79 years old) N=147		Very elderly group (≥80 years old) N=470		
	Total data		Total data		Total data		*p-value*
Vital signs on admission	617		147		470		
Pulse rate, bpm		83.0 ± 22.5		86.5 ± 24.0		82.0 ± 21.9	0.034
Sinus rhythm		312 (50.6)		82 (55.8)		230 (48.9)	0.252
Atrial fibrillation		247 (40.0)		55 (37.4)		192 (40.9)	
SBP, mmHg		133.6 ± 29.8		136.5 ± 32.6		132.7 ± 28.9	0.183
DBP, mmHg		76.5 ± 19.6		79.4 ± 22.3		75.6 ± 18.6	0.040
Clinical scenario[a]	575		134		441		
CS1 SBP>140		237 (41.2)		59 (44.0)		178 (40.4)	
CS2 SBP 100-140		286 (49.7)		65 (48.5)		221 (50.1)	0.673
CS3 SBP<100		52 (9.0)		10 (7.5)		42 (9.5)	
Chest X-ray on admission							
CTR, %	590	63.2 ± 7.5	138	60.4 ± 6.5	452	64.1 ± 7.6	<0.001
Pulmonary congestion	593	401 (67.6)	139	91 (65.5)	454	310 (68.3)	0.535
Pleural effusion	592	422 (71.3)	139	98 (70.5)	453	324 (71.5)	0.816
Blood chemical analysis on admission	552		129		423		
BNP, pg/mL	357	1002.8 ± 1206.7	77	865.0 ± 838.6	280	1040.7 ± 1288.3	0.259
NT-ProBNP, pg/mL	195	5957.4 ± 3190.4	52	4609.5 ± 3198.6	143	6447.6 ± 3053.5	<0.001
BNP <100 or NT-proBNP <400		26 (4.7)		8 (6.2)		18 (4.3)	
BNP 100-199 or NT-proBNP 400-899		43 (7.8)		12 (9.3)		31 (7.3)	0.667
BNP 200-499 or NT-proBNP 900-1999		112 (20.3)		24 (18.6)		88 (20.8)	
BNP ≥500 or NT-proBNP ≥2000		371 (67.2)		85 (65.9)		286 (67.6)	
Echocardiogram							
LAD, mm	396	45.9 ± 9.2	105	46.1 ± 9.8	291	45.9 ± 9.0	0.863
IVST, mm	394	10.3 ± 2.5	105	10.0 ± 1.9	289	10.4 ± 2.7	0.193
PWT, mm	394	10.3 ± 3.4	105	10.1 ± 1.9	289	10.4 ± 3.8	0.479
LVEDD, mm	394	50.1 ± 9.6	105	52.8 ± 9.7	289	49.2 ± 9.4	0.001
LVESD, mm	394	37.0 ± 10.8	105	39.4 ± 11.2	289	36.1 ± 10.6	0.001
EF (Teich) , %	392	52.0 ± 16.1	105	50.0 ± 15.9	287	52.8 ± 16.2	0.126
≥50 (HFpEF)		227 (57.9)		53 (50.5)		174 (60.6)	0.196
<40 (HFrEF)		99 (25.3)		31 (29.5)		68 (23.7)	
Valvular function							
Moderate or worse AS	428	71 (16.6)	112	5 (4.5)	316	66 (20.9)	<0.001
Moderate or worse AR	426	93 (21.8)	112	18 (16.1)	314	75 (23.9)	0.086
Moderate or worse MR	428	240 (56.1)	112	58 (51.8)	316	182 (57.6)	0.287

Variables are expressed as mean ± SD or numbers (%).
[a]This table excludes patients transferred from another hospital in a stable conditionAR, aortic regurgitation; AS, aortic stenosis; CS, clinical scenario; CTR, cardiothoracic ratio in chest X-ray; DBP, diastolic blood pressure; EF, ejection fraction; HFpEF, heart failure with preserved EF; HFrEF, heart failure with reduced EF; IVST, interventricular septal thickness; LAD, left atrial diameter; LVEDD, left ventricular end diastolic diameter; LVESD, left ventricular end systolic diameter; MR, mitral regurgitation; PWT, posterior wall thickness; SBP, systolic blood pressure.

with BI ≥85, and all-cause mortality was higher in patients with BI <40. Similarly, hospitalizations for any cause and HF were suggested to be lower in patients with BI ≥85.

Discussion

In this study, we focused on data obtained from elderly patients with HF because the mean lifespan of Japanese citizens in 2017 was 81.09 years for men and 87.26 years for women, both higher than 80 years. Thus, we conducted a comparative analysis of participants aged ≥80 years, who account for the Japanese population's progressive aging. Additionally, we investigated elderly patients with HF hospitalized in community-based hospitals and not in fully equipped cardiovascular centers. As expected from study's initiation, the in-hospital outcomes were severe. Overall, 16.9% died, 14.4% had to be transferred to terminal institutes, and 65.9% were discharged to their own homes. This tendency was particularly remarkable in very elderly patients. This may be an actual outcome in elderly patients with HF in a super-aged society.

The present study clarified the following 5 points. First, older patients with HF were mainly octogenarians. Second, these patients had high care needs, so the need of individualized care support was important. Third, elderly patients with HF faced a high burden in terms of time and manpower for HF treatment and nursing care and life support. Fourth, the decline in ADLs due to hospitalization could be improved by multidisciplinary team care during hospitalization, including appropriate comprehensive rehabilitation. Last, as a trend, the improved ADLs scores at discharge might be reflected in the prognosis of elderly patients with HF.

In the Japanese Registry of All Cardiac and Vascular Diseases-Diagnosis Procedure Combination (JROAD-DPC) study, a national survey using 2012 DPC data from 610 certified cardiovascular hospitals,[13] the mean ages of patients with HF were 75 years in men and 81 years in women. In regional cohort studies in Osaka (the KICK-OFF Registry)

Table 3. Inhospital Outcomes of the Surviving Patients

	All patients N=513		Elderly group (65-79 years old) N=141		Very elderly group (≥80 years old) N=372		
	Total data		Total data		Total data		*p-value*
Residence after discharge	513		141		372		
Own home		407 (79.3)		122 (86.5)		285 (76.6)	
Nursing home		89 (17.3)		15 (10.6)		74 (19.9)	0.040
Hospital (patient transfer)		17 (3.3)		4 (2.8)		13 (3.5)	
ADL score (BI) at discharge	513	80 [45-100]	141	100 [80-100]	372	65 [30-100]	<0.001
Mobility score>=10		356 (69.4)		115 (81.6)		241 (64.8)	<0.001
Toilet use score=10		295 (57.5)		109 (77.3)		186 (50.0)	<0.001
ΔBI[a]		22.9 ± 35.7		21.4 ± 37.6		23.0 ± 35.0	0.633
Chest X-ray at discharge							
CTR, %	328	58.2 ± 7.2	93	56.3 ± 6.4	235	59.0 ± 7.3	0.002
Pulmonary congestion	328	47 (14.3)	93	11 (4.7)	235	36 (15.3)	0.416
Pleural effusion	328	91 (27.7)	93	21 (22.6)	235	70 (29.8)	0.189
Medication at discharge	513		141		372		
Number of agents		7.4 ± 3.5		7.6 ± 3.5		7.3 ± 3.5	0.350
Diuretics		412 (80.3)		113 (80.1)		299 (80.4)	0.952
ACEi/ARB		251 (48.9)		81 (57.4)		170 (45.7)	0.017
MR antagonists		196 (38.2)		56 (39.7)		140 (37.6)	0.665
β blocker		279 (54.4)		92 (65.2)		187 (50.3)	0.002
Ca channel blocker		178 (34.7)		57 (40.4)		121 (32.5)	0.093
Cardiotonic agents		41 (8.0)		12 (8.5)		29 (7.8)	0.790
Anti-arrythmic agents		30 (5.8)		10 (7.1)		20 (5.4)	0.460
Anti-coagulation		255 (49.7)		78 (55.3)		177 (47.6)	0.118
Warfarin		122 (23.8)		33 (23.4)		89 (23.9)	0.914
DOAC		135 (26.3)		46 (32.6)		89 (23.9)	0.044
Anti-platelet		137 (26.7)		41 (29.1)		96 (25.8)	0.455
Anti-diabetic		85 (16.6)		35 (24.8)		50 (13.4)	0.002
Lipid-lowering agents		111 (21.6)		38 (27.0)		73 (19.6)	0.072
Statins		99 (19.3)		37 (26.2)		62 (16.7)	0.014
Anti-hyperuricemic		122 (23.8)		38 (27.0)		84 (22.6)	0.299
Hypnotic agents		142 (27.7)		29 (20.6)		113 (30.4)	0.027
Benzodiazepine		118 (23.0)		23 (16.3)		95 (25.5)	0.027
Gastrointestinal agents		374 (72.9)		100 (70.9)		274 (73.7)	0.534
Laxatives		195 (38.0)		43 (30.5)		152 (40.9)	0.031

Variables are expressed as mean ± SD, median [interquartile range], or numbers (%).
[a]ΔBI= BI score at discharge − BI score on admissionACEi, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor brocker; BI, Barthel index; CTR, cardiothoracic ratio in chest X-ray; DOAC, direct oral anticoagulant; MR antagonist, mineralocorticoid receptor antagonist.

and Hiroshima (the REAL-HF Registry), the mean ages were 78.2 and 79 years, respectively.[14,15] The mean age in our study cohort was higher than in those reports, possibly because our cohort was limited to elderly patients with HF or because of regional differences based on the age ratio. The JROAD-DPC study included a large number of patients from a fully equipped institute. In the KICK-OFF and REAL-HF studies, not all patients hospitalized due to HF

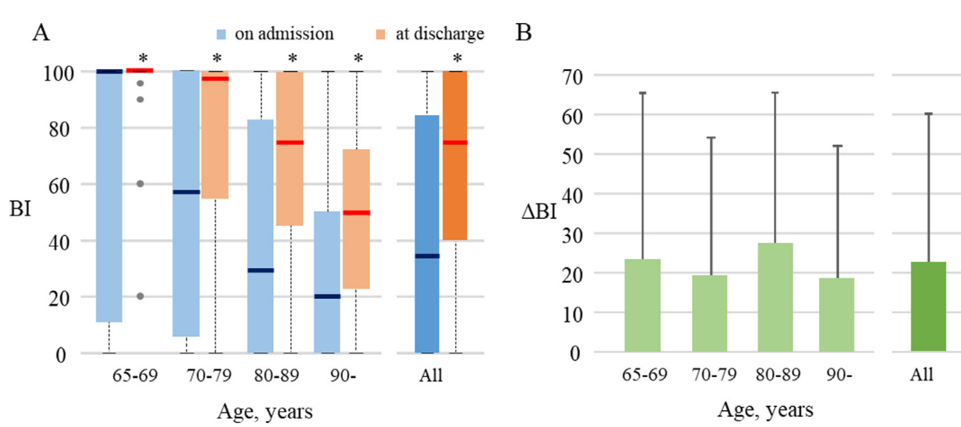

Fig. 2. Efficacy of rehabilitation on the activities of daily living (ADLs) score among survivors who underwent rehabilitation. (**A**) ADL score by age group. Box-and-whisker plot showing median BI, interquartile ranges (IQRs) (boxes) and 1.5 × IQR (whiskers). Outliers are plotted as individual dots. (**B**) Change in ADL score (ΔBI = BI score at discharge−BI score on admission) by age group. Data are shown as mean ± standard deviation. **P* < 0.05 compared with the BI score on admission. ADL, activities of daily living; BI, Barthel Index.

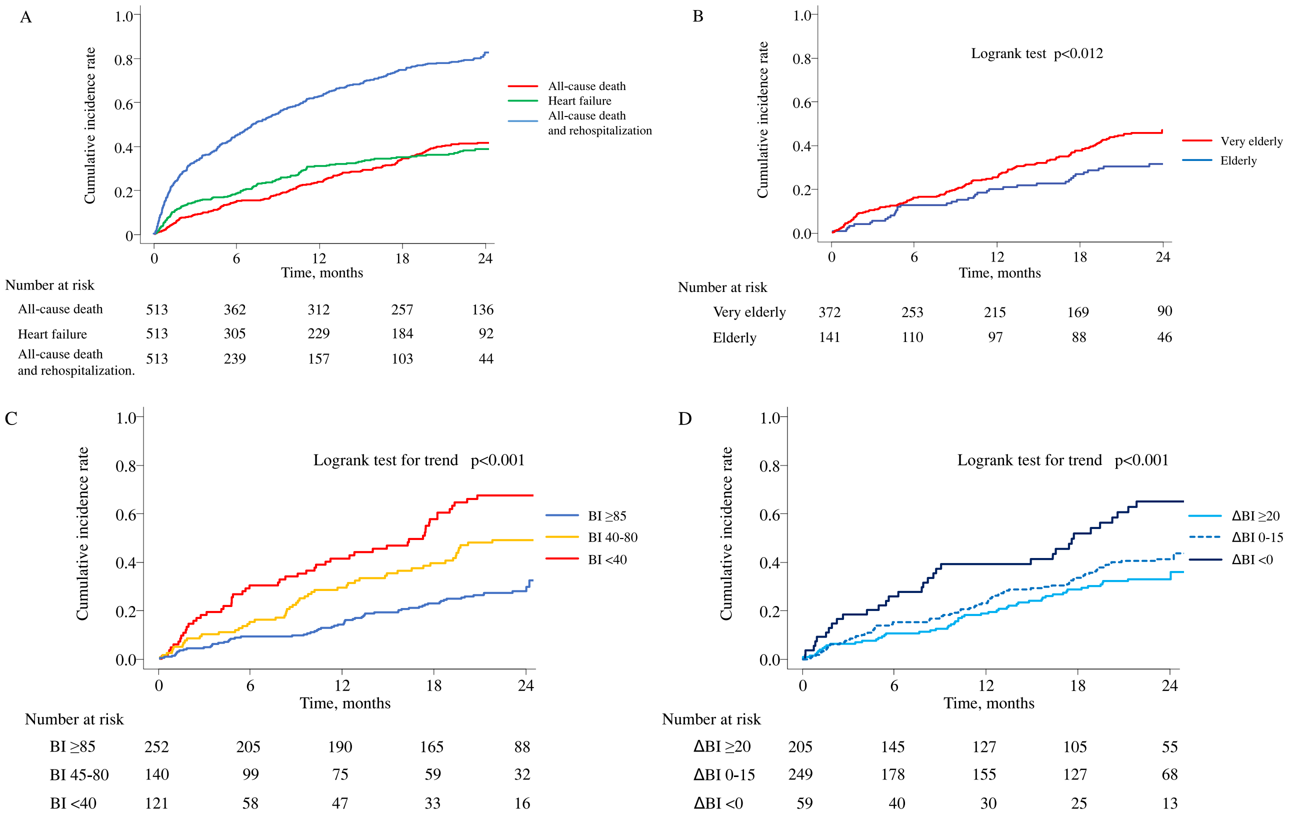

Fig. 3. Analyses of clinical events. (**A**) Kaplan-Meier curves showing the occurrence of clinical events up to 2 years postdischarge. (**B**) Kaplan-Meier curves showing the occurrence of all-cause death up to 2-years postdischarge by age group. (**C**) Kaplan-Meier curves showing the occurrence of all-cause death up to 2 years postdischarge by BI score. (**D**) Kaplan-Meier curves showing the occurrence of all-cause death up to 2 years postdischarge by ΔBI score. ΔBI, BI score at discharge−BI score on admission.

were registered. Thus, our data may provide a real clinical picture because data were obtained from all inpatients with HF in community-based hospitals.

The elderly patients with HF were underweight and had poor nutritional status. Additionally, there was a high incidence of comorbidities, such as cognitive disorders and

Table 4. Multivariate Cox Proportional Hazard Models of Independent Predictors of All-Cause Mortality

All-cause mortality	Model 1			Model 2			Model 3		
	N = 508			N = 455			N = 374		
	HR	95% CI	*P* value	HR	95% CI	*P* value	HR	95% CI	*P* value
ADL (BI at discharge, per 5 points)	0.946	(0.926−0.967)	<0.001	0.949	(0.927−0.971)	<0.001	0.942	(0.914−0.971)	<0.001
Age (per 1 year)	1.034	(1.012−1.057)	0.002	1.036	(1.013−1.059)	0.002	1.034	(1.008−1.061)	0.009
Male (yes vs no)	1.454	(1.060−1.994)	0.020	1.477	(1.032−2.030)	0.032	1.328	(0.899−1.963)	0.155
BMI on admission (per 1 kg/m^2)	0.959	(0.922−0.997)	0.035	0.965	(0.925−1.008)	0.107	0.967	(0.910−1.027)	0.268
BNP severity[a]	-	-	-	1.048	(0.854−1.287)	0.653	0.996	(0.797−1.244)	0.968
CTR on admission (per 1%)	-	-	-	1.004	(0.989−1.020)	0.582	0.998	(0.980−1.016)	0.846
Anemia (yes vs no)[b]	-	-	-	-	-	-	1.001	(0.671−1.493)	0.998
Hypoalbuminemia (yes vs no)[c]	-	-	-	-	-	-	1.678	(0.956−2.948)	0.071
Hyponatremia (yes vs no)[d]	-	-	-	-	-	-	1.477	(0.932−2.340)	0.097
Renal dysfunction (yes vs no)[e]	-	-	-	-	-	-	1.529	(0.936−2.497)	0.090
Nutritional disorder (yes vs no)[f]	-	-	-	-	-	-	0.584	(0.296−1.154)	0.122

ADLs, activities of daily living; BI, Barthel Index; BMI, body mass indx; BNP, B-type natriuretic peptide; CTR, cardiothoracic ratio in chest X-ray; DBP, diastolic blood pressure; Hb, hemoglobin; NT-proBNP, N-terminal pro-B-type natriuretic peptide; EF, ejection fraction; HFpEF, heart failure with preserved EF; HFrEF, heart failure with reduced EF; IVST, interventricular septal thickness; LAD, left atrial diameter; LVEDD, left ventricular end diastolic diameter; LVESD, left ventricular end systolic diameter; MR, mitral regurgitation; PWT, posterior wall thickness; SBP, systolic blood pressure.

[a]BNP levels on admission were analyzed as a continuous variable, coded as: 1, very mildly elevated = BNP <100 pg/mL or NT-proBNP <400 pg/mL; 2, mildly elevated = BNP 100−199 pg/mL or NT-proBNP 400-899 pg/mL; 3, moderately elevated = BNP200−499 pg/mL or NT-proBNP 900-1999 pg/mL; and 4, severely elevated = BNP ≥500 pg/mL or NT-proBNP ≥2000 pg/mL.

[b]Male: Hb <13 g/dL; female: Hb <12 g/dL on admission.

[c]Serum albumin <3.4 g/dL on admission.

[d]Serum Na <136 mmol/L on admission.

Table 5. Clinical Outcomes After Hospital Discharge

Variable	All patients N=513		BI ≥ 85 N=252		BI 40-80 N=140		BI < 40 N=121	
		Events/ pt-year		Events/ pt-year		Events/ pt-year		Events/ pt-year
All cause death, N (%)	170 (33.1)	0.270	63(25.0)	0.167	54 (38.6)	0.341	53 (43.8)	0.560
Cardiovascular death, N (%)	70 (13.6)	0.111	28 (11.1)	0.074	26 (18.6)	0.164	16 (13.2)	0.169
Hospitalization for any-cause, N (%)	298 (58.1)		156 (61.9)		86 (61.4)		56 (46.3)	
Total N of hospitalization events	696	1.394	371	1.277	217	1.617	108	1.450
N of hospotalization/pt								
0	134 (26.1)		74 (29.4)		31 (22.1)		29 (24.0)	
1	136 (26.5)		65 (25.8)		38 (27.1)		33 (27.3)	
2	63 (12.3)		40 (15.9)		14 (10.0)		9 (7.4)	
≥3	99 (19.3)		51 (20.2)		34 (24.3)		14 (11.6)	
Hospitalization for HF, N (%)	140 (27.3)		78 (31.0)		44 (31.4)		18 (14.9)	
Total N of hospitalization events	270	0.500	156	0.477	82	0.637	32	0.379
N of hospotalization/pt								
0	292 (56.9)		152 (60.3)		73 (52.1)		67 (55.4)	
1	79 (15.4)		43 (17.1)		24 (17.1)		12 (9.9)	
2	28 (5.5)		17 (6.7)		9 (6.4)		2 (1.7)	
≥3	33 (6.4)		43 (17.1)		11 (7.9)		4 (3.3)	

BI, Barthel index; HF, heart failure; pt, patient.

motor disorders, diseases that directly affect ADLs. On admission, more than half of the elderly patients with HF and 66.8% of those in the very elderly group were already at a stage requiring long-term care insurance. Although many of the very elderly patients were residents of nursing homes, approximately half of the patients in each group lived alone or with others, suggesting that many of them were living with a heavy personal burden. ADLs scores on admission were particularly low in the very elderly patients, with 67.9% unable to walk unaided and 77.2% unable to use the toilet independently; self-care was highly unfeasible. These facts suggest that the elderly patients with HF essentially require disease management and personalized-care support, possibly achieved by comprehensive rehabilitation.[16] This would permit elderly patients with HF to keep their dignity until the end of life and would allow their enormous age-related burdens to be reduced. The long hospitalization period is noteworthy and will be discussed in the context of Japan's medical system. In Japan, a lump-sum payment system based on DPC[17] has been established, and similar to the diagnosis-related group/prospective payment system in the United States, there is an incentive to shorten the average length of stay. According to DPC, the length of stay is set in 3 levels, with Hospitalization Period II being based on the national average length of stay. Reimbursement is added if the patient is discharged earlier than Hospitalization Period I and deducted if the patient stays longer. For example, the average hospital stay for "heart failure" not requiring surgical treatment is set at 19 days. Even under this Japanese reimbursement system, the results showed that the length of stay for elderly patients with HF is extremely long, and the financial burden on hospitals and the insurance burden on medical expenses are high.

Cardiac rehabilitation was necessary for 70.5% of the elderly patients with HF, and an even higher proportion of the very elderly patients. Regarding the low ADLs at admission, correlation analysis showed that it was not related to factors contributing to the severity of HF at admission, but to patients' prehospital status, such as age and level of care, as well as to hemoglobin and nutritional status at admission. We speculate that there may be a cumulative effect of prehospital patient-care status, nutritional status and conditions caused by HF at the time of admission. Our data on the survivors showed that ADLs scores were significantly improved at discharge. The degree of improvement (ΔBI) was not different between the very elderly and the elderly groups, with approximately 20 points attainable in both. The ADLs score improvement cannot be explained simply by the direct effect of the rehabilitation but as a synergistic effect of disease management and comprehensive rehabilitation, irrespective of age. The proportion of those in the very elderly group capable of walking or using the toilet independently on discharge was small; these activities must be susceptible to aging. Thus, it is crucial to assess the prehospital ADLs and the degree of decline in ADLs by hospitalization for the very elderly in the future. To activate cardiac rehabilitation for elderly patients with HF, it is encouraging to note that a BI of approximately 20 points could be attained in a suitable manner regardless of age. Assuming this improvement, comprehensive rehabilitation might be recommended as early as possible. Thus, this early intervention may be a useful measure to further reduce the burden of HF in elderly patients.

The mortality rate was very high, exceeding 20% at 1 year and 40% at 2 years, with HF being the most common cause. Regarding the rehospitalization for any cause, the event rate was approximately 60%, due mainly to HF. An analysis of mortality and ADL scores showed that mortality was higher in the elderly with lower ADL scores and less improvement. We believe our findings suggest that it is crucial to increase both the improvement and the achievement of ADLs at discharge. ADLs score on discharge was an independent prognostic factor corrected for age, sex and BMI, and this was true in further models incorporating the HF severity and other extracardiac prognostic factors. Previous studies have emphasized that patients with BI scores of <60 on discharge have higher rates of death and HF-associated events,[18] and patients whose ADL scores decline during hospitalization are more likely to die or experience HF-related events after discharge.[19] However, in our analysis, there was no association between HF rehospitalization and ADL scores. Repeated hospital admissions are an issue with HF, so we investigated the association between ADLs scores and the number of readmissions during follow-up. Moreover, as seen in Table 5, we can assume that elderly patients with HF with ADLs scores of ≥85 who are considered independent in self-care have fewer repeated HF hospitalizations and deaths. Meanwhile, elderly patients with HF and with ADLs scores of <40, close to being bedridden, may have fewer repeated hospitalizations due to more mortality events.

These results also suggest that it is important to attempt to improve ADLs to achieve self-care independence in any way by discharge time and to maintain greater control of ADLs after discharge by applying comprehensive rehabilitation for every elderly patient with HF. In contrast, for elderly patients with HF with ADL scores <40, special considerations should be incorporated into the advanced-care planning for dignity maintenance at the end-of-life period.

Limitations and Future Tasks

In elderly patients with HF, not all data were obtainable because several patients were uncooperative due to their condition. Herein, the existence of missing data was inevitable; in this case, we attempted to specify the concrete cause. Nevertheless, we do not believe that this factor has hindered clarification of the real figure of HF in elderly patients in a super-aged society. We aimed to emphasize the complete enrollment of all the patients. This issue is always common so as to promote studies of HF in a super-aged society. Regarding outcomes during hospitalization and prognosis, our study did not show the effect of the rehabilitation intervention alone because it was not an intervention study that included a control group without rehabilitation.

Here, we summarized the data obtained up to 2 years postdischarge so as to report how comprehensive cardiac rehabilitation of elderly patients with HF improves their ADLs and prognoses and reduces the burden on the aging society. In the near future, as an extension of the present study, we intend to investigate their quality of life.

Conclusions

Elderly patients with HF in the super-aged society were mainly octogenarians, indicating ages older than 80 years. These patients were frail and, thus, required disease management and personalized-care support through comprehensive cardiac rehabilitation. Although their ADLs scores improved with the intervention, those scores at discharge were closely associated with their survival prognoses. In the management of HF in the very elderly, it is necessary to consider not only hemodynamic and fluid management but also prognosis prediction focusing on ADLs. Any intentions to improve inhospital and postdischarge ADLs of elderly patients with HF are tasks that will reduce the enormous burden in the future.

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Authors' contributions

HO, TI and MI contributed to the conception or design of the work; HO, MY, WM, KS, SN, and TM contributed to the acquisition or analysis of data; HO and TI drafted the manuscript. All authors gave final approval and agreed to be accountable for all aspects of the work ensuring integrity and accuracy.

Conflicts of Interest

None

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