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# Impact of inpatient cardiac rehabilitation on Barthel Index score and prognosis in patients with acute decompensated heart failure

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ABSTRACT

*Background:* Although cardiac rehabilitation (CR) can improve exercise capacity and quality of life in patients with chronic heart failure (HF), the long-term prognostic influence of inpatient CR on patients with acute decompensated HF (ADHF) is not well established. We examined the impact of inpatient CR on disability and prognosis in patients with ADHF.

*Methods:* A total of 171 patients admitted for ADHF underwent CR that included resistance training and aerobic exercise. Patient disability was evaluated using Barthel Index (BI) scores at pre- ($BI_{pre}$) and post- ($BI_{post}$) rehabilitation. All-cause mortality was retrospectively recorded after discharge.

*Results:* In the study cohort (median age: 76 years), 46 patients experienced all-cause mortality during a median of 478 days of follow-up. Impaired $BI_{post}$ (i.e., BI < 60) was significantly correlated with older age and lower albumin, hemoglobin, estimated glomerular filtration rate (eGFR), and B-type natriuretic peptide (BNP). In Kaplan-Meier analysis, impaired $BI_{pre}$ and $BI_{post}$ were significantly associated with all-cause mortality. Better outcomes were observed for improved BI ($\Delta BI > 15$) among patients with impaired baseline BI. $BI_{post}$ was an independent predictor of all-cause mortality after adjusting for age, sex, eGFR, BNP, hemoglobin, albumin, and left ventricular ejection fraction.

*Conclusions:* Inpatient CR led to improvements in disabilities among patients with ADHF. Baseline disabilities were associated with a poor prognosis. Greater improvements in BI to inpatient CR were significantly related to better outcomes in patients with impaired baseline BI. CR should be indicated for patients with ADHF.



## 1. Introduction

Heart failure (HF) is predominantly a disease of the elderly [1]. The prevalence of multimorbidity also increases with age [2], with elderly patients having five to six comorbidities in addition to HF [3–5]. Frequently coexisting frailty and disability affect quality of life across the entire age spectrum of patients with HF [6]. A recent study described that frailty and disability impacted 30-day mortality in older patients with acute decompensated HF (ADHF) in emergency departments [7]. Thus, broader interventions beyond HF management are necessary for frail patients, including the treatment of concurrent decompensated chronic conditions, reduction of polypharmacy, monitoring of patient capacities during and after hospitalization to minimize disability, and prescription of physical exercise and nutritional supplementation [8,9].

Cardiac rehabilitation (CR) provides secondary prevention of cardiovascular disease and is an essential component of patient care [10]. A Cochrane meta-analysis of exercise-based CR in patients with HF reported significant improvements in health-related quality of life and a reduction in re-hospitalization [11]. Exercise training is a core component of comprehensive rehabilitation programs that is currently recommended in combination with pharmacological therapy for patients with chronic HF with reduced ejection fraction (EF) based on a class 1 level of evidence [12,13]. The benefits of exercise-based CR for clinically relevant health outcomes (e.g., functional capacity, exercise tolerance, and quality of life) have been widely recognized in patients with chronic HF [14]. Although positive effects on HF-related hospitalization and mortality rates in chronic HF populations have also been reported [15–17], the influence of inpatient CR on disability and long-term outcomes in patients with ADHF is not well established.

The physical impairment associated with chronic HF often worsens markedly with decompensation and can be further compounded by

*Abbreviations:* ADHF, Acute Decompensated Heart Failure; BI, Barthel Index; BMI, Body Mass Index; BNP, B-type Natriuretic Peptide; CI, Confidence Interval; CR, Cardiac Rehabilitation; eGFR, Estimated Glomerular Filtration Rate; ECG, Electrocardiogram; EF, Ejection Fraction; HF, Heart Failure; LV, Left Ventricular.

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prolonged immobility in the hospital environment, which may cause profound declines in physical function [18]. Functional impairments can persist and even progress after hospital discharge [19] and are associated with increased risks of adverse clinical outcomes, including re-hospitalization and death [19–21]. To improve cardiac care outcomes, this study examined the impact of inpatient CR on patient disability and prognosis among hospitalized patients with ADHF.

## 2. Methods

### 2.1. Study design and patient population

Consecutive patients with ADHF discharged Shinshu University Hospital from July 2014 to July 2018 were retrospectively screened. Of 239 patients who discharged after heart failure treatment without acute coronary syndrome, 45 patients were not indicated inpatient CR because of preserved functional status. One hundred ninety-four patients were indicated inpatient CR. Of these, disability data at both pre- and post CR were available in 171 patients. The hospital's inpatient CR program including resistance training and aerobic exercise were indicated as soon as hemodynamic stability was achieved. Data were collected during the compensated HF state prior to discharge. Other recorded findings included medical history, medication, laboratory data, electrocardiogram (ECG) and echocardiography reports, discharge status, and post-discharge follow-up. Patient disability was evaluated using the Barthel Index (BI) [22,23] before and after the CR program. This study was approved by the Shinshu University Institutional Review Board. Informed consent was obtained from each patient. All procedures were performed in accordance with the Declaration of Helsinki. The diagnoses of ADHF and acute coronary syndrome were made by the attending clinicians using all available data on symptoms, laboratory results, ECGs, echocardiography, and coronary angiograms. Clinical data were collected at the time of scheduled follow-up and by telephone call to each patient. The primary outcome was all-cause mortality. Survival status was ascertained by chart review.

### 2.2. Inpatient CR

The supervised CR program at Shinshu University Hospital consisted of two exercise stages. The first stage comprised basic activity training, such as sitting up in bed, sit-to-stand motions, self-care, and walking within the ward, which were started as soon as possible after the patient became hemodynamically stable. After completing the first stage, patients proceeded to the second stage that involved progressive combined exercises of stretching, resistance, and aerobic training according to the American College of Sports Medicine's guidelines for exercise testing and prescription [24] and the Japanese Circulation Society's guidelines for rehabilitation of inpatients with cardiovascular disease (JCS 2012) [25]. A typical exercise prescription for the second stage consisted of a 5-day-per week program of 30 min of aerobic activity (walking or bicycle ergometer) and resistance training (squats, calf raises, and weight training) at a Karvonen intensity value of 0.3–0.5 or Borg scale value of 11–13 [25]. In patients with severe HF, a 3-day-per week program of lower intensity would be indicated. The CR exercise program was carried out for approximately 2 weeks during hospitalization unless the patient showed adverse symptoms or events.

### 2.3. Assessment of disability

The BI is a 10-item scoring scale used to measure a patient's functional ability to perform basic activities of daily living [22,23]. The items can be divided into two groups: those related to self-care (feeding, grooming, bathing, dressing, bowel and bladder care, and toilet use) and those concerning mobility (ambulation, transfers, and stair climbing). The score ranges from zero, representing a totally dependent bedridden state, to 100, which represents complete independence. In the present study, BI scores were determined by a physical therapist at pre- ($BI_{pre}$) and post- ($BI_{post}$) CR program. The cutoff BI value used to divide the patients into two groups was 60 in accordance with a previous study demonstrating the characteristics of severe functional dependence [26]. An impaired BI state (<60) aided in determining prognosis in patients with acute HF [26]. Median ΔBI value ($BI_{post} - BI_{pre}$) was used to assess the impact of BI improvement on prognosis of our cohort.

## 3. Statistical analysis

Continuous variables are expressed as the mean ± standard deviation when normally distributed and as the median and interquartile range when non-normally distributed. Normality was assessed by the Shapiro-Wilk W-test. Spearman's rank correlation was used as a non-parametric measure of associations between BI and clinical and echocardiographic indices. The Wilcoxon or Kruskal-Wallis rank sums tests were adopted to compare differences in BI across clinical categories, while proportions were tested using contingency table analyses. Kaplan-Meier survival plots were created from baseline to the time of an adverse event and compared using the log-rank test. The Cox proportional hazards regression model was employed to assess the clinical risk associated with increasing continuous standardized increments of BI scores. The proportional hazards assumption was verified with log (time) vs. log (−log [survival]) plots. Statistical analyses were performed using SPSS Statistics software for Windows, version 22 (IBM Corp., Armonk, NY, US). All p-values reported are from two-sided tests. A $p$-value of <0.05 was considered statistically significant.

## 4. Results

### 4.1. Study population

The baseline clinical characteristics of the 171 patients in this study are summarized in Table 1. For the study population as a whole, $BI_{pre}$ was evaluated on the 5th (range: 3–8) day after admission, CR 1st stage was performed from 5th (range: 3–8) day and 2nd stage was initiated 10th (range: 7–14) day, and CR was performed and $BI_{post}$ was evaluated on day 16 (range: 8–32) of hospitalization. Median $BI_{pre}$ and $BI_{post}$ were 70 (range: 50–85) and 90 (range: 80–100), respectively ($p < 0.001$). Patients with impaired $BI_{pre}$ tended to be older, female, and have lower albumin and hemoglobin than did those with preserved $BI_{pre}$ (Table 1). $BI_{post}$ worsened with increasing age ($r = -0.502$, $p < 0.001$) and decreasing BMI ($r = 0.207$, $p = 0.004$) (Supplemental Table).

### 4.2. Relationship between BI and clinical characteristics

Lower magnitudes (i.e., more impaired) of $BI_{post}$ were significantly correlated with left ventricular (LV) structure (LV end-diastolic volume index: $r = 0.233$, $p = 0.005$) and LV ejection fraction (LVEF) ($r = -0.197$, $p = 0.007$). Greater impairments of $BI_{post}$ were associated with worsening estimated glomerular filtration rate (eGFR) ($r = 0.183$, $p = 0.011$), hemoglobin level ($r = 0.255$, $p < 0.001$), and serum albumin concentration ($r = 0.376$, $p < 0.001$) (Supplemental Table).

### 4.3. Predictors of cardiac events

The endpoint of all-cause mortality occurred in 20% of patients (46/171) during a median follow-up of 478 (range: 157–862) days. Impaired $BI_{post}$ was significantly related to an increased risk of all-cause mortality (44% vs. 17%, $p < 0.01$) in patients with ADHF, while impaired $BI_{pre}$ was not (28% vs. 18%, $p = 0.126$) (Supplemental Figure). In Kaplan-Meier testing, impaired $BI_{pre}$ and $BI_{post}$ predicted long-term all-cause mortality (Fig. 1A, B). When patients were divided into two groups according to baseline BI, better outcomes were observed in those who showed improved BI (ΔBI > 15) after CR in the impaired baseline BI ($BI_{pre} < 60$) cohort (Fig. 1C, D). This result suggested that patients with impaired baseline BI should be indicated for inhospital CR as soon as hemodynamic conditions stabilize to improve outcomes. In multivariate Cox proportional hazards analysis, impaired $BI_{post}$ predicted all-cause mortality following adjustments for age, sex, BNP, eGFR, hemoglobin, albumin, and LVEF, while $BI_{pre}$ did not (Table 2). In impaired $BI_{pre}$ cohort, ΔBI > 15 was independently associated with better outcome following adjustments for age, sex, BNP, eGFR, hemoglobin, albumin, and LVEF (Table 3).

## 5. Discussion

This study demonstrated the prognostic significance of BI for predicting mortality in patients with ADHF following CR. Specifically, it showed that: 1) inpatient CR provided significant improvements in previous disabilities among patients with ADHF; 2) lower BI values were associated with all-cause mortality; 3) Better outcomes were observed for improved BI (ΔBI > 15) among patients with impaired

baseline BI; and 4) $BI_{post}$ was an independent predictor of all-cause mortality after adjusting for age, sex, BNP, eGFR, hemoglobin, albumin, and LVEF.

### 5.1. Inpatient CR for ADHF

Studies on exercise training for HF have focused almost exclusively on chronic, stable patients [27]. Although the benefits of exercise-based CR on clinically relevant health outcomes (e.g., mortality, rehospitalization, functional capacity, exercise tolerance, and quality of life) have been widely recognized [14–17], the patient populations in these investigations were hemodynamically stable and hospitalized patients with ADHF were excluded. Thus, limited data exist on inpatient CR for ADHF. Our findings provide important clinical information regarding the impact of inpatient CR for hospitalized patients with ADHF on disabilities and prognosis.

A previous report described that inpatient CR soon after discharge from the acute care setting improved the 1-year outcome of patients with ADHF [17]. Scrutinio et al. conducted an observational study of hospitalized patients with ADHF comparing 1-year outcomes between CR participants (n = 130) and non-participants (n = 145) [28], in which propensity score-adjusted Cox-multivariate analysis showed the relative risk of the primary outcome among CR participants to be 0.58 (p = 0.04, 95% confidence interval 0.34–0.99). Our study supports this result based on a larger CR cohort of elderly patients with ADHF.

### 5.2. Mechanism of effect of inpatient CR on prognosis

Improvement in exercise capacity is one of the most reliable effects of exercise training. The improvement is assumed to be due to improvements in peripheral effects such as peripheral circulation and skeletal muscle function in patients with HF [29,30]. Resistance training is expected to enhance the strength of major muscle groups, facilitate daily activities, and improve quality of life of patients with HF and low muscle strength [31]. Exercise training improves heart rate variability and baroreflex sensitivity [32–34] and ameliorates the increasing cardiovascular risk linked with autonomic derangements in patients with HF [35–39]. The benefits of exercise on functional capacity and ventilator efficiency for inpatients with HF are mainly due to peripheral mechanisms and

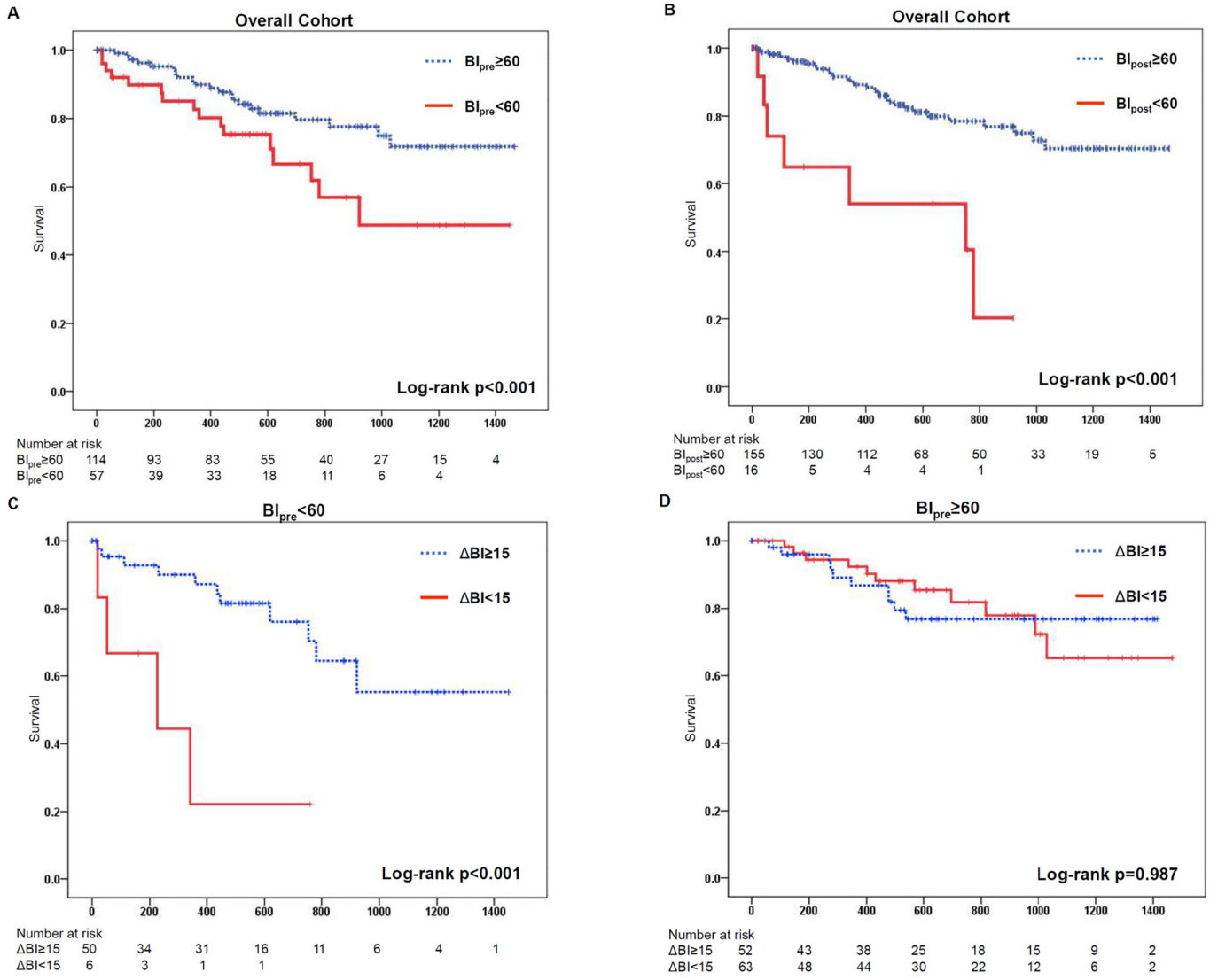


**Fig. 1.** Risk stratification of mortality using Barthel Index score. In Kaplan-Meier analysis, impaired $BI_{pre}$ (A) and $BI_{post}$ (B) were associated with long-term all-cause mortality in the overall cohort. Greater improvements in BI (ΔBI ≥ 15) on inpatient CR were significantly related to better outcomes in the impaired $BI_{pre}$ ($BI_{pre}$ < 60) cohort (C). In the $BI_{pre}$ ≥60 cohort, ΔBI was not associated with outcomes (D). $BI_{pre}$, Barthel Index score before cardiac rehabilitation; $BI_{post}$, Barthel Index score after cardiac rehabilitation; CR, cardiac rehabilitation.

**Table 1**
Baseline characteristics.

| Variable | $BI_{pre}$ < 60 | | | $BI_{pre}$ ≥ 60 (n = 115) | *p*-Value[a] |
|---|---|---|---|---|---|
| | Total (n = 56) | ΔBI ≥ 15 (n = 50) | ΔBI < 15 (n = 6) | | |
| Age (years) | 83 [77, 87] | 83 [76, 86] | 83 [78, 88] | 72 [66, 82] | <0.001 |
| Male, n (%) | 26 (46) | 21 (42) | 5 (83) | 79 (69) | 0.013 |
| Body mass index (kg/m$^2$) | 19.8 [18.5, 22.0] | 19.8 [18.7, 23.2] | 20.1 [17.8, 21.2] | 20.9 [18.5, 24.1] | 0.149 |
| $BI_{pre}$ | 40 [25, 50] | 40 [24, 45] | 53 [26, 55] | 80 [70, 85] | <0.001 |
| $BI_{post}$ | 83 [61, 90] | 85 [70, 90] | 43 [13, 60] | 93 [85, 100] | <0.001 |
| Heart failure history | | | | | |
| NYHA Class III or IV, n (%) | 20 (36) | 17 (34) | 3 (50) | 28 (24) | 0.114 |
| Ischemic etiology, n (%) | 27 (48) | 24 (48) | 3 (50) | 29 (25) | 0.002 |
| Valvular disease, n (%) | 17 (30) | 15 (30) | 2 (33) | 34 (30) | 0.890 |
| Atrial fibrillation, n (%) | 33 (59) | 28 (56) | 5 (83) | 61 (53) | 0.322 |
| Heart rate (beats/min) | 73 [64, 82] | 71 [64, 80] | 81 [67, 91] | 69 [59, 80] | 0.096 |
| Systolic blood pressure (mmHg) | 107 [99, 121] | 111 [102, 121] | 101 [96, 127] | 111 [99, 123] | 0.876 |
| Comorbidities | | | | | |
| Hypertension, n (%) | 33 (59) | 30 (60) | 3 (50) | 62 (54) | 0.505 |
| Diabetes mellitus, n (%) | 22 (39) | 21 (42) | 1 (17) | 36 (31) | 0.287 |
| Medications | | | | | |
| ACE-I and/or ARBs, n (%) | 46 (82) | 45 (90) | 1 (17) | 98 (85) | 0.703 |
| β-Blockers, n (%) | 40 (71) | 40 (80) | 0 (0) | 86 (74) | 0.645 |
| Spironolactone, n (%) | 30 (54) | 27 (54) | 2 (33) | 68 (59) | 0.533 |
| Loop diuretics, n (%) | 48 (86) | 42 (84) | 5 (83) | 91 (79) | 0.277 |
| Echocardiographic data | | | | | |
| LVEF (%) | 50 [38, 60] | 50 [34, 60] | 48 [44, 68] | 45 [32, 56] | 0.098 |
| LVEDV index (mL/m$^2$) | 66 [44, 84] | 66 [47, 86] | 73 [48, 78] | 68 [48, 91] | 0.514 |
| LVESV index (mL/m$^2$) | 35 [19, 52] | 36 [21, 52] | 35 [24, 43] | 36 [19, 61] | 0.717 |
| Mitral E/A ratio | 0.9 [0.6, 1.4] | 0.9 [0.7, 1.4] | – | 1.3 [0.7, 1.9] | 0.042 |
| Mitral DT (ms) | 165 [125, 208] | 165 [129, 210] | 127 [100, 166] | 164 [138, 226] | 0.330 |
| Laboratory data | | | | | |
| Albumin (g/dL) | 3.3 [2.9, 3.5] | 3.3 [2.9, 3.5] | 3.2 [2.8, 3.7] | 3.6 [3.3, 4.0] | <0.001 |
| Hemoglobin (g/dL) | 10.8 [10.1, 11.9] | 10.9 [10.1, 11.7] | 11.5 [10.0, 13.9] | 11.8 [10.4, 13.8] | 0.006 |
| eGFR (mL/min/1.73 m$^2$) | 36 [27, 53] | 36 [27, 52] | 35 [20, 43] | 45 [31, 60] | 0.064 |
| BNP (pg/mL) | 354 [186, 602] | 356 [191, 625] | 411 [98, 672] | 269 [138, 452] | 0.085 |

[a] $BI_{pre}$ < 60 vs. $BI_{pre}$ ≥ 60. ACE—I, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; BI, Barthel Index; BNP, B-type natriuretic peptide; DT, deceleration time; E/A, early to late diastolic flow velocity ratio; EF, ejection fraction; eGFR, estimated glomerular filtration rate; EDV, end-diastolic volume; ESV, end-systolic volume; LV, left ventricular; NYHA, New York Heart Association.

adaptations [29,35–39]. Hospitalization by ADHF deteriorates physical function including exercise capacity, skeletal muscle strength, ventilatory volume, peripheral circulation, autonomic nerve activity [18–21]. Our results indicate that early CR intervention may be beneficial for preventing the disability progression induced by bed-rest during treatment for HF.

**Table 2**
Univariate and multivariate Cox proportional hazards analyses.

| Variable | HR (95% CI) | *p*-Value |
|---|---|---|
| $BI_{post}$ | 0.960 (0.946–0.975) | <0.001 |
| $BI_{pre}$ | 0.980 (0.968–0.992) | 0.002 |
| Multivariable model | | |
| $BI_{post}$ | | |
| Adjusted for: | | |
| Age, sex, BNP | 0.972 (0.954–0.990) | 0.002 |
| Age, sex, eGFR | 0.971 (0.954–0.989) | 0.001 |
| Age, sex, hemoglobin | 0.971 (0.954–0.988) | 0.001 |
| Age, sex, albumin | 0.972 (0.954–0.990) | 0.002 |
| Age, sex, LVEF | 0.969 (0.952–0.987) | 0.001 |
| $BI_{pre}$ | | |
| Adjusted for: | | |
| Age, sex, BNP | 0.987 (0.973–1.002) | 0.081 |
| Age, sex, eGFR | 0.989 (0.975–1.003) | 0.131 |
| Age, sex, hemoglobin | 0.990 (0.976–1.005) | 0.179 |
| Age, sex, albumin | 0.992 (0.977–1.008) | 0.315 |
| Age, sex, LVEF | 0.990 (0.975–1.004) | 0.165 |

BI, Barthel Index; BNP, B-type natriuretic peptide; CI, confidence interval; eGFR, estimated glomerular filtration rate; HR, hazard ratio; LVEF, left ventricular ejection fraction.

### 5.3. Clinical implications

Most patients hospitalized for ADHF are frail elderly patients with multiple comorbidities, including deficits in mobility, strength, and balance [18,39]. These functional impairments may deteriorate after hospital discharge [19] and are associated with increased risks of mortality [19–21]. Our findings corroborate the potential benefit of offering physical function intervention to patients hospitalized with ADHF. Indeed, inpatient CR is currently indicated for patients with ADHF at our institution and should be broadly indicated among elderly patients with ADHF. This study also showed a positive impact of CR using risk stratification of BI for mortality. Thus, BI scores may be adopted as a measure for the goals and success of CR.

**Table 3**
Univariate and multivariate Cox proportional hazards analyses in low $BI_{pre}$ group.

| Variable | HR (95% CI) | *p*-Value |
|---|---|---|
| ΔBI ≥ 15 | 0.174 (0.052–0.582) | 0.005 |
| Multivariate model | | |
| ΔBI ≥ 15 | | |
| Adjusted for: | | |
| Age | 0.230 (0.069–0.764) | 0.016 |
| Sex | 0.179 (0.046–0.693) | 0.013 |
| BNP | 0.195 (0.054–0.700) | 0.012 |
| eGFR | 0.221 (0.066–0.738) | 0.014 |
| Hemoglobin | 0.125 (0.035–0.445) | 0.001 |
| Albumin | 0.196 (0.059–0.653) | 0.008 |
| LVEF | 0.217 (0.065–0.728) | 0.013 |

BI, Barthel Index; BNP, B-type natriuretic peptide; CI, confidence interval; eGFR, estimated glomerular filtration rate; HR, hazard ratio; LVEF, left ventricular ejection fraction.

## 6. Limitations

This study had several limitations. First, because of the retrospective nature of this study, follow-up period was short and distribution of the period was widely variated. Thus, censored data might affect the robustness of our survival rate and hazard ratio estimation in Kaplan-Meier analysis and Cox regression. Second, because we enrolled patients who were discharged after treatment for HF, data regarding inpatient mortality were limited. Third, our study population was heterogeneous; we enrolled patients regardless HF phenotype (i.e., reduced EF, mid-range EF, and preserved EF). The generalizability of CR for each HF subtype should be studied in a larger cohort. Fourth, the timing of CR initiation, period and its overall intensity were left to each physician's and physical therapist's discretion, respectively. Severity of HF might cause variations of CR period. Prospective trial with uniform CR and follow-up protocol in patients with homogenous severity HF would be preferable to investigate the impact of CR on the prognosis. Fifth, although a prognostic impact of inpatient CR in patients with preserved $BI_{pre}$ was not observed, the clinical merits of CR for those patients should be discussed with a greater number of patients and wider scales for disability. Since BI was suitable for identifying patients with more impaired daily activity, its dispersion should be narrowed in patients with preserved daily activity; a larger scale of daily activity and more patients are needed to assess for associations between disability and clinical outcome in those patients. Finally, limited data were available regarding outpatient CR in this study. Despite these limitations, inpatient CR proved to be a straightforward approach with the promise of clinical utility for improving disabilities and prognosis among hospitalized patients with ADHF.

## 7. Conclusions

Inpatient CR could improve previous disabilities among patients with ADHF. Impaired baseline disability was associated with a poor prognosis. Greater improvements in BI to inpatient CR were significantly related to better outcomes in patients with impaired baseline BI, who should therefore be indicated for this regimen.

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## Relationship with industry

None.

## Conflict of interest

The authors report no relationships that could be construed as a conflict of interest.

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## References

[1] L.H. Curtis, D.J. Whellan, B.G. Hammill, et al., Incidence and prevalence of heart failure in elderly persons, 1994–2003, Arch. Intern. Med. 168 (2008) 418–424.
[2] A. Marengoni, S. Angleman, R. Melis, et al., Aging with multimorbidity: a systematic review of the literature, Ageing Res. Rev. 10 (2011) 430–439.
[3] G.E. Caughey, E.E. Roughead, S. Shakib, A.I. Vitry, A.L. Gilbert, Co-morbidity and potential treatment conflicts in elderly heart failure patients: a retrospective, cross-sectional study of administrative claims data, Drug Aging 28 (2011) 575–581.
[4] H. Krum, R.E. Gilbert, Demopraphics and concomitant disorders in heart failure, Lancet 362 (2003) 147–158.
[5] C.W. Yancy, M. Jessup, B. Bozkurt, et al., 2017 ACCF/AHA guideline for the management of heart failure: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Failure Society of America, J. Am. Coll. Cardiol. 70 (2017) 776–803.
[6] P. Gastelurrutia, J. Lupon, S. Altimir, et al., Effect of fragility on quality of life in patients with heart failure, Am. J. Cardiol. 112 (2013) 1785–1789.
[7] F.J. Martín-Sánchez, E. Rodríguez-Adrada, M.T. Vidan, et al., Impact of frailty and disability on 30-day mortality in older patients with acute heart failure, Am. J. Cardiol. 120 (2017) 1151–1157.
[8] M.A. Fiatarone, E.F. O'Neill, N.D. Ryan, et al., Exercise training and nutritional supplementation for physical frailty in very elderly people, N. Engl. J. Med. 330 (1994) 1769–1775.
[9] T.P. Ng, L. Feng, M.S. Nyunt, et al., Nutritional, physical, cognitive, and combination interventions and frailty reversal among older adults: a randomized controlled trial, Am. J. Med. 128 (2015) 1225–1236.
[10] Cardiac Rehabilitation Guidelines, McCreery C, Cradock K, Fallon N, Dublin. Irish Association of Cardiac Rehabilitation, 2013. (November 7, 2018 at http://www.iacr.info/about/guidelines/).
[11] R.S. Taylor, V.S. Sagar, E.J. Davies, et al., Exercise-based rehabilitation for heart failure, Cochrane Database Syst. Rev. 4 (2014), CD003331. https://doi.org/10.1002/14651858.CD003331.pub4.
[12] M.F. Piepoli, U. Corrà, W. Benzer, et al., A position paper from the Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation, Eur J Cardiovasc Prev Rehabil 17 (2010) 1–17.
[13] I.L. Pina, C.S. Apstein, G.J. Balady, et al., Exercise and heart failure. A statement from the American Heart Association Committee on Exercise, Rehabilitation, and Prevention, Circulation 107 (2003) 1210–1225.
[14] J. Downing, G.J. Balady, The role of exercise training in heart failure, J. Am. Coll. Cardiol. 58 (2011) 561–569.
[15] C.M. O'Connor, D.J. Whellan, K.L. Lee, et al., Efficacy and safety of exercise training in patients with chronic heart failure: HF-ACTION randomized controlled trial, JAMA 301 (2009) 1439–1450.
[16] M.F. Piepoli, C. Davos, D.P. Francis, A.J. Coats, ExTraMATCH Collaborative, Exercise training meta–analysis of trials in patients with chronic heart failure (ExTraMATCH), BMJ 328 (2004) 189–196.
[17] S.J. Keteyian, E.S. Leifer, N. Houston-Miller, et al., Relation between volume of exercise and clinical outcomes in patients with heart failure, J. Am. Coll. Cardiol. 60 (2012) 1899–1905.
[18] H.M. Krumholz, Post-hospital syndrome–an acquired, transient condition of generalized risk, N. Engl. J. Med. 368 (2013) 100–102.
[19] E. Delgado Parada, F.M. Suárez García, V. López Gaona, S. Gutiérrez Vara, J.J. Solano Jaurrieta, Mortality and functional evolution at one year after hospital admission due to heart failure (HF) in elderly patients, Arch. Gerontol. Geriatr. 54 (2012) 261–265, https://doi.org/10.1016/j.archger.2011.03.004.
[20] M.T. Alahdab, I.N. Mansour, S. Napan, T.D. Stamos, Six minute walk test predicts long-term all-cause mortality and heart failure rehospitalization in African-American patients hospitalized with acute decompensated heart failure, J. Card. Fail. 15 (2009) 130–135.
[21] N.V. Kommuri, M.L. Hohnson, T.M. Koelling, Six-minute walk distance predicts 30-day readmission inpatientized heart failure patients, Arch. Med. Res. 41 (2010) 363–368.
[22] F.I. Mahoney, D.W. Barthel, Functional evaluation: the Barthel index, Md State Med J 14 (1965) 61–65.
[23] Martin–Sanchez FJ, M. Christ, O. Miro, et al., Practical approach on frail older patients attended for acute heart failure, Int. J. Cardiol. 222 (2016) 62–71.
[24] Baltimore Lippincott Williams & Wilkins, ACSM's Guidelines for Exercise Testing and Prescription, 7th ed. American College of Sports Medicine, 2005.
[25] JCS Joint Working Group, Guidelines for rehabilitation inpatients with cardiovascular disease (JCS 2012), Circ. J. 78 (2014) 2022–2093.
[26] F.J. Martin-Sanchez, V. Gil, P. Llorens, et al., Barthel Index-Enhanced Feedback for Effective Cardiac Treatment (BI-EFFECT) study: contribution of the Barthel Index to the Heart Failure Risk Scoring System model in elderly adults with acute heart failure in the emergency department, J. Am. Geriatr. Soc. 60 (2012) 493–498.
[27] E.J. Davies, T. Moxham, K. Rees, et al., Exercise training for systolic heart failure: Cochrane systematic review and meta-analysis, Eur. J. Heart Fail. 12 (2010) 706–715, https://doi.org/10.1093/eurjhf/hfq056.
[28] D. Scurutinio, A. Passantino, R. Catanzaro, et al., Inpatient cardiac rehabilitation soon after hospitalization for acute decompensated heart failure: a propensity score study, J Cardiopulm Rehabil Prev 32 (2012) 71–77.
[29] R. Hambrecht, S. Gielen, A. Linke, et al., Effects of exercise training on left ventricular function and peripheral resistance in patients with chronic heart failure: a randomized trial, JAMA 283 (2000) 3095–3101.
[30] M.J. Sullivan, M.B. Higginbotham, F.R. Cobb, Exercise training in patients with severe left ventricular dysfunction: hemodynamic and metabolic effects, Circulation 78 (1988) 506–515.
[31] V.M. Conraads, P. Beckers, J. Vaes, et al., Combined endurance/resistance training reduces NT-proBNP levels in patients with chronic heart failure, Eur. Heart J. 25 (2004) 1797–1805.
[32] A.J.S. Coats, S. Adamopoulos, A. Radaelli, et al., Controlled trial of physical training in chronic heart failure: exercise performance, hemodynamics, ventilation and autonomic function, Circulation 85 (1992) 2119–2131.
[33] S. Adamopoulos, P. Ponikowski, E. Cerquetani, et al., Circadian pattern of heart rate variability in chronic heart failure patients. Effects of physical training, Eur. Heart J. 16 (1995) 1380–1386.

[34] M.G. Gademan, C.A. Swenne, H.F. Verwey, et al., Effect of exercise training on autonomic derangement and neurohumoral activation in chronic heart failure, J Cardiac Fail 13 (2007) 294–303.
[35] G.E. Billman, Cardiac autonomic neural remodeling and susceptibility to sudden cardiac death: effect of endurance exercise training, Am. J. Phys. 297 (2009) 1171–1193.
[36] E. Crimi, L.J. Ignarro, F. Cacciatore, C. Napoli, Mechanisms by which exercise training benefits patients with heart failure, Nat. Rev. Cardiol. 6 (2009) 292–300.
[37] A.L. Clark, Poole–Wilson PA, A.J. Coats, Exercise limitation in chronic heart failure: central role of the periphery, J. Am. Coll. Cardiol. 28 (1996) 1092–1102.
[38] R. Hambrecht, J. Niebauer, E. Fiehn, et al., Physical training in patients with stable chronic heart failure: effects on cardiorespiratory fitness and ultrastructural abnormalities of leg muscles, J. Am. Coll. Cardiol. 25 (1995) 1239–1249.
[39] K. Murad, D.W. Kitzman, Frailty and multiple comorbidities in the elderly patient with heart failure: implications for management, Heart Fail. Rev. 17 (2012) 581–588.