Prognostic Importance of Multiple Nutrition Screening Indexes for 1-Year Mortality in Hospitalized Acute Decompensated Heart Failure Patients

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Background: The purpose of the study was to evaluate the impact of nutritional status on 1-year mortality in hospitalized patients with acute decompensated heart failure (ADHF).

Methods and Results: We enrolled 457 hospitalized ADHF patients. Previously established objective nutritional indexes (controlling nutritional status [CONUT], prognostic nutritional index [PNI], geriatric nutritional risk index [GNRI], and subjective global assessment [SGA]) were evaluated at hospital admission. Malnutrition was defined as CONUT score ≥5, PNI score <38, GNRI score <92, and SGA scores B and C. The frequencies of malnutrition based on CONUT, PNI, GNRI, and SGA were 31.5%, 21.4%, 44.9%, and 27.8%, respectively. All indexes were related to the occurrence of 1-year mortality on univariate Cox regression analysis (P<0.05). We constructed a reference model using age, body mass index, systolic blood pressure, sodium concentration, and renal function on multivariable Cox regression analysis. Adding SGA to the reference model significantly improved both net reclassification improvement (NRI) and integrated discrimination improvement (0.344, P=0.002; 0.012, P=0.049; respectively). Other indexes (CONUT, PNI, and GNRI scores) significantly improved NRI (0.254, P=0.019; 0.273, P=0.013; 0.306, P=0.006; respectively).

Conclusions: Nutritional screening assessed at hospital admission was appropriate for the prediction of 1-year mortality in hospitalized patients with ADHF.

Key Words: Acute heart failure; Nutrition assessment; Prognosis
GNRI = 1.489 × serum albumin (g/dL) + 41.7 × (weight / WLo)
Ideal weight was calculated from the Lorentz equations (WLo) as follows:

For men: H (cm) - 100 - [(H (cm) - 150)/4]
For women: H (cm) - 100 - [(H (cm) - 150)/2.5]

When weight exceeded WLo, we set weight/WLo = 1.

>98: normal, 92-98: mild risk, 82-92: moderate risk, <82: severe risk

Body mass index (BMI) was calculated using the following formula: BMI = mass (kg)/height² (m²). We defined anemia as serum hemoglobin <13 mg/dL in men and <12 mg/dL in women.

Previously established objective nutritional indexes (controlling nutritional status [CONUT], prognostic nutritional index [PNI], geriatric nutritional risk index [GNRI], and subjective global assessment [SGA]) were evaluated at hospital admission. The control criteria are shown in Figure 1. CONUT score was determined using serum albumin level, total lymphocyte count, and total lymphocyte count. The formula was as follows: CONUT score = albumin score (≥3.5 g/dL; 0 points; 3.0–3.4 g/dL; 2 points; 2.5–2.9 g/dL; 4 points; <2.5 g/dL; 6 points) + total lymphocyte score (≥1,600/μL; 0 points; 1,000–1,599/μL; 1 point; 800–1,999/μL; 2 points; <800/μL; 3 points) + total cholesterol score (≥180 mg/dL; 0 points; 140–179 mg/dL; 1 point; 100–139 mg/dL; 2 points; <100 mg/dL; 3 points). PNI score was calculated using serum albumin level and total lymphocyte count. The formula was as follows: PNI = 10 × serum albumin (g/dL) + 0.005 × total lymphocyte count (μL). GNRI score was calculated using serum albumin level, and body weight and height. The formula was as follows:

Statistical Analysis
The distribution of continuous variables was examined using the Shapiro-Wilk test. Continuous variables are expressed as median (IQR), and categorical variables as n (%). Comparison of continuous variables was performed using the Student’s t-test or Mann-Whitney U-test. Categorical variables were analyzed using the chi-squared test or Fisher’s exact probability test. All baseline variables with P<0.05 on univariate Cox regression analysis were entered into multivariate Cox regression analysis to determine independent predictors of 1-year mortality.

We then defined the baseline model, which included factors significantly and independently associated with
Eighty-one patients died (17.7%) within 1 year. The rate of cardiovascular and non-cardiovascular death was 70.4% and 29.6%, respectively. Seventy-nine patients (17.3%) were re-admitted due to heart failure within 1 year. The average age was 79 years (IQR, 70–86 years), and 53.4% of the patients were male. Patients who died were significantly older (P<0.001), whereas BMI, systolic blood pressure (SBP), diastolic blood pressure, heart rate, and the frequency of hypertensive heart disease were significantly higher in patients who survived (P<0.05). With regard to laboratory data, blood urea nitrogen, serum potassium, serum creatinine, and brain-type natriuretic peptide were significantly different in the two groups, as shown in Table 1.

### Table 1. Subject Characteristics vs. Survival Status

| Parameter                                      | Total       | Died        | Survived    | P-value  |
|------------------------------------------------|-------------|-------------|-------------|----------|
| No. subjects (n)                               | 457         | 81          | 376         |          |
| Age (years)                                    | 79.0 (70.0–86.0) | 84.0 (78.5–90.0) | 78.0 (69.0–84.0) | <0.001*  |
| Male gender                                    | 53.4        | 48.2        | 54.5        | 0.298    |
| BMI (kg/m²)                                    | 22.4 (19.9–25.1) | 20.6 (18.8–22.8) | 22.7 (20.4–25.6) | <0.001*  |
| Current or former smoking (%)                  | 43.5        | 38.3        | 44.7        | 0.289    |
| SBP (mmHg)                                     | 156 (129–188) | 137 (120–175) | 161 (133–189) | <0.001*  |
| DBP (mmHg)                                     | 88 (72–107)  | 78 (60–94)  | 91 (74–110) | <0.001*  |
| Heart rate (beats/min)                         | 102 (86–125) | 98 (81–114) | 105 (87–125) | 0.045*   |

Data given as % or median (IQR). *P<0.05. AF, atrial fibrillation; API, atrial flutter; BMI, body mass index; BNP, brain-type natriuretic peptide; BUN, blood urea nitrogen; CRP, C-reactive protein; DBP, diastolic blood pressure; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; FPG, fasting plasma glucose; Hb, hemoglobin; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; LVEF, left ventricular ejection fraction; NGSP, National Glycohemoglobin Standardization Program; SBP, systolic blood pressure; TC, total cholesterol; TG, triglycerides; WBC, white blood cells.

### Results

Baseline patient characteristics are listed in Table 1.
We compared malnutrition between the 2 groups (Figure 3). In patients who died, malnutrition was observed in 42.0% based on CONUT score, 32.1% based on PNI score, 60.5% based on GNRI score, and 45.7% based on SGA score. In patients who survived, malnutrition was observed in 29.3% based on CONUT score, 19.2% based on PNI score, 41.5% based on GNRI score, and 23.9% based on SGA. In all indexes, malnutrition was significantly more prevalent in patients who died than in those who survived (P<0.05; Figure 4).

We examined predictors of 1-year mortality on univariate and multivariate Cox regression analyses (Table 2). Variables with P<0.05 on univariate Cox regression analysis were included in the multivariate Cox regression analysis. Age, BMI, SBP, eGFR, and serum sodium were significantly associated with 1-year mortality in this study. Therefore, we defined the baseline model using age, BMI, SBP, eGFR, and serum sodium.

Finally, we calculated the C-index, NRI, and IDI (Table 3). Adding each nutrition index to the baseline model improved the prediction of 1-year mortality compared with the baseline model alone (P<0.05). The addition of CONUT, PNI, or GNRI score significantly improved NRI (P<0.05). The addition of SGA significantly improved both NRI and IDI (P<0.05).

Discussion

The principal findings of this study were as follows: (1) malnutrition was a predictor of 1-year mortality even in patients with ADHF (similar to the results obtained in a previous study involving patients with chronic heart failure); and (2) adding each nutrition index improved the prediction of 1-year outcome in hospitalized patients with ADHF.

Low BMI or sarcopenia is related to poor prognosis in patients with heart failure.11-14 In contrast, some reports suggest that the severity of chronic disease contributes to frailty status.15 The frailty cycle centered on sarcopenia is attracting attention with regard to chronic diseases that

![Figure 2. Distribution of malnutrition according to nutrition index. Abbreviations as in Figure 1.](image)

![Figure 3. Prevalence of malnutrition according to nutrition index and survival status. Abbreviations as in Figure 1.](image)
Prognostic Importance of Nutrition Screening

CONUT score is a nutritional screening tool used in various fields. It is a screening tool used to comprehensively evaluate protein metabolism, immunity, and lipid metabolism. PNI is a nutritional screening tool that has been proposed in the field of surgery to evaluate nutritional status and immunity. GNRI is often used for nutritional screening in elderly people. It is also used for nutritional screening in patients undergoing hemodialysis. These nutrition indexes include albumin level, total cholesterol level, and lymphocyte count proportions to some degree. Objective nutrition indexes may also provide additional prognostic information in patients with chronic heart failure. Therefore, we thought that screening using these indexes at the time of admission would be useful to predict 1-year mortality in this study.

SGA is a nutrition screening tool that consists of 5 interviews and 5 physical examinations including both subjective and objective assessments. SGA has been used in patients of almost all ages and can also evaluate the risk of delayed healing or infection. In addition, SGA is a subjective comprehensive evaluation that has a significant correlation with albumin level, total cholesterol level, and total lymphocyte count. SGA is also related to sarcopenia. In addition, sarcopenia has also been reported as

Figure 4. Kaplan-Meier curves for all-cause mortality-free survival up to 1 year according to malnutrition status using (A) CONUT score; (B) PNI score; (C) GNRI score; and (D) SGA. Abbreviations as in Figure 1.
an independent predictor in patients with chronic heart failure. SGA has also been suggested to be a useful nutritional screening tool for chronic heart failure. SGA is an indicator that considers both malnutrition and sarcopenia. This simple score enables all medical staff to evaluate comprehensive nutritional status easily. Moreover, this assessment does not change with timing, indicating sufficient reproducibility. Therefore, SGA might have the greatest advantage because it can be evaluated using only subjective assessments.

In chronic heart failure, nutrition occupies an important position. Stratifying nutrition status at hospital admission in patients with ADHF can lead to an early response by a nutrition support team (NST) and a multifaceted approach, such as cardiac rehabilitation from the acute phase of hospitalization. Taken together, this could reduce the poor prognosis of ADHF.

### Study Limitations

This study had several limitations. First, it involved only a small number of enrolled patients and was conducted at a single center. Second, nutritional screening also differs depending on the etiology of heart failure. It was difficult, however, to analyze the data for each etiology of death because of the small number of enrolled patients. As a result, larger sample sizes and multicenter studies are needed. Finally, we evaluated these nutrition indexes only at hospital admission. Additional screening should be done during the hospital stay or at discharge.

### Table 2. Indicators of 1-Year Mortality

| Parameter                  | Univariate analysis | Multivariate analysis |
|----------------------------|---------------------|-----------------------|
|                            | P-value             | HR (95% CI)           | P-value     | HR (95% CI)          |
| Age (years)                | <0.001*             | 1.06 (1.04–1.09)      | 0.001*      | 1.04 (1.02–1.07)     |
| Male gender (%)            | 0.249               | 0.88 (0.71–1.09)      |            |                    |
| BMI (kg/m²)                | <0.001*             | 0.86 (0.80–0.91)      | <0.001*     | 0.89 (0.83–0.96)     |
| SBP (mmHg)                 | <0.001*             | 0.99 (0.98–1.00)      | 0.005*      | 0.99 (0.99–1.00)     |
| DBP (mmHg)                 | <0.001*             | 0.98 (0.97–0.99)      |            |                    |
| Heart rate (beats/min)     | 0.063               | 0.99 (0.98–1.00)      |            |                    |
| Serum TC (mg/dL)           | 0.002*              | 0.99 (0.98–1.00)      |            |                    |
| Serum TG (mg/dL)           | 0.617               | 1.00 (0.99–1.00)      |            |                    |
| Serum HDL-C (mg/dL)        | 0.005*              | 0.97 (0.95–0.99)      |            |                    |
| Serum LDL-C (mg/dL)        | 0.004*              | 0.99 (0.98–1.00)      |            |                    |
| FPG (mg/dL)                | 0.866               | 1.00 (1.00–1.00)      |            |                    |
| Blood HbA1c (NGSP, %)      | 0.062               | 0.78 (0.57–1.01)      |            |                    |
| BUN (mg/dL)                | <0.001*             | 1.04 (1.03–1.05)      |            |                    |
| Serum sodium (mEq/L)       | 0.025*              | 0.95 (0.92–0.99)      | 0.044*      | 0.96 (0.92–1.00)     |
| Serum potassium (mEq/L)    | <0.001*             | 1.62 (1.23–2.10)      |            |                    |
| Serum creatinine (mg/dL)   | <0.001*             | 1.23 (1.11–1.35)      |            |                    |
| eGFR (mL/min/1.73m²)       | <0.001*             | 0.98 (0.97–0.99)      | 0.007*      | 0.99 (0.97–1.00)     |
| Serum uric acid (mg/dL)    | 0.091               | 1.08 (0.99–1.18)      |            |                    |
| Serum albumin (mg/dL)      | 0.005*              | 0.55 (0.37–0.83)      |            |                    |
| Serum CRP (mg/L)           | 0.092               | 1.05 (0.99–1.10)      |            |                    |
| BNP (pg/mL)                | 0.036*              | 1.00 (1.00–1.00)      |            |                    |
| WBC (10³/μL)               | 0.216               | 1.00 (1.00–1.00)      |            |                    |
| Total lymphocytes (/μL)    | 0.024*              | 1.00 (1.00–1.00)      |            |                    |
| Hb (mg/dL)                 | <0.001*             | 0.79 (0.72–0.87)      |            |                    |
| Anemia (%)                 | <0.001*             | 1.85 (1.40–2.55)      | 0.079       | 1.30 (0.97–1.82)     |
| LVEF (%)                   | 0.217               | 1.01 (0.99–1.03)      |            |                    |

*P<0.05. Abbreviations as in Table 1.

### Table 3. Predictive Model Discrimination for 1-Year Mortality

| Parameter                  | C-index (95% CI) | P-value | NRI | P-value | IDI | P-value |
|----------------------------|-----------------|---------|-----|---------|-----|---------|
| Baseline model             | 0.769 (0.716–0.823) | Ref. | Ref. | Ref. |     |         |
| Baseline+CONUT score       | 0.771 (0.717–0.825) | 0.743  | 0.254 | 0.019*  | 0.003 | 0.192  |
| Baseline+PNI               | 0.772 (0.718–0.826) | 0.604  | 0.273 | 0.013*  | 0.005 | 0.130  |
| Baseline+GNRI             | 0.770 (0.716–0.824) | 0.874  | 0.306 | 0.006*  | 0.002 | 0.358  |
| Baseline+SGA             | 0.779 (0.726–0.832) | 0.259  | 0.344 | 0.012*  | 0.002 | 0.049* |

*P<0.05. Baseline model included age, BMI, SBP, eGFR, and serum sodium. CONUT, controlling nutritional status; GNRI, geriatric nutritional index; IDI, integrated discrimination improvement; NRI, net reclassification improvement; PNI, prognostic nutrition index; SGA, subjective global assessment. Other abbreviations as in Table 1.
Conclusions
Nutrition screening at hospital admission might improve the prediction of 1-year mortality in hospitalized patients with ADHF. Nutrition screening at hospital admission could be useful for the stratification of ADHF patients.

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Supplementary Files
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