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Controlling Nutritional Status Score Predicts 1-Year Outcomes in Chronic Thromboembolic Pulmonary Hypertension

Takeshi Adachi, MD; Shiro Adachi, MD, PhD; Yoshihisa Nakano, MD, PhD; Itsumure Nishiyama, MD; Miku Hirose, MD; Toyoaki Murohara, MD, PhD

Background: The prognosis for patients with chronic thromboembolic pulmonary hypertension (CTEPH) using their nutritional status has not been established. We investigated the relationship between the prognosis of patients with CTEPH and the Controlling Nutritional Status (CONUT) score, which is a nutritional assessment tool.

Methods and Results: A total of 157 patients with CTEPH was enrolled in the study. The primary outcome was defined as the composite outcome of all-cause mortality and non-elective hospitalization due to heart failure. Receiver operating characteristic (ROC) curve analysis was used to determine the cutoff CONUT score for predicting the 1-year rate of the primary outcome. Patients were divided into 2 groups according to the significant cutoff value and compared. Undernutrition was observed in 51.6% of patients. ROC analysis revealed a significant cutoff CONUT score of 3.5 (area under the curve=0.789). The incidence rate of the primary composite outcome was higher in the high CONUT group (score ≥4) than in the low CONUT group (score ≤3; 20% vs. 2.2%; P<0.001). Cox analysis revealed the CONUT score per point increase was an independent risk factor for the primary composite outcomes (hazard ratio 2.301; 95% confidence interval 1.081–4.895; P=0.031).

Conclusions: The CONUT score can predict the 1-year rate of all-cause death and non-elective hospitalization in patients with CTEPH.

Key Words: Follow-up study; Nutritional assessment; Pulmonary hypertension

Chronic thromboembolic pulmonary hypertension (CTEPH) is a rare disease characterized by pulmonary vascular remodeling and increased pulmonary vascular resistance (PVR) caused by a chronic pulmonary artery thrombus, leading to right heart failure and even death.[1,2] Although the prognosis in CTEPH has been improved by pulmonary endarterectomy (PEA), balloon pulmonary angioplasty (BPA), and drug therapy in past decades,[3–5] some patients do not respond well to these treatments. Therefore, other risk factors need to be identified and addressed.[1]

Undernutrition is a common comorbid condition among patients with cardiovascular diseases, such as heart failure,[6] coronary artery disease,[7] and acute pulmonary embolism.[8] Evaluating nutritional status can effectively predict the prognosis in these diseases. In the absence of a consensus on the nutritional assessment of patients with pulmonary hypertension, several studies have reported a relationship between malnutrition and pulmonary hypertension based on assessments of serum albumin levels,[9] body mass index (BMI),[10] Geriatric Nutritional Risk Index (GNRI),[11] and the prognostic nutritional index.[12] However, an independent assessment of serum albumin level is not sufficient for nutritional evaluation.[13] Nutritional assessment using BMI may be insufficient in obtaining a prognostic evaluation of cardiovascular disease because some cardiovascular diseases are associated with the 'obesity paradox'.[14] The relationship between prognosis and BMI has been controversial in heart failure[15] and pulmonary hypertension.[16,17] Furthermore, the research on nutritional evaluation and prognosis in patients with pulmonary hypertension has mostly focused on pulmonary arterial hypertension (PAH),[9,10,12] and less on CTEPH,[11] which evaluates the prognosis in patients with PAH or

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Department of Cardiology (T.A., S.A., T.M.), Center for Advanced Medicine and Clinical Research, Department of Advanced Medicine (Y.N.), Nagoya University Hospital, Nagoya; Department of Cardiology, Nagoya University Graduate School of Medicine, Nagoya (I.N., M.H.), Japan

T.M. is a member of *Circulation Reports*' Editorial Team.

Mailing address: Shiro Adachi, MD, PhD, Department of Cardiology, Nagoya University Hospital, 65 Tsurumai-cho, Showa-ku, Nagoya, Aichi 466-8560 Japan. email: sadachi@med.nagoya-u.ac.jp

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Table 1. Baseline Characteristics of the Study Population

	All patients (n=157)
Age (years)	62.7±14.3
Female	88 (64.2)
Hypertension	44 (32.1)
Diabetes	16 (11.8)
Former smoker	43 (32.1)
Statin use	28 (17.8)
Body mass index	24.3±4.7
WHO-FC	
I	1 (0.7)
II	60 (43.8)
III	72 (52.6)
IV	4 (2.9)
Albumin (g/dL)	3.9±0.3
Total cholesterol (mg/dL)	190±35
Lymphocytes (/μL)	1725±699
BNP (pg/mL)	57.3 [20.5–207.7]
CRP (mg/dL)	0.10 [0.05–0.30]
eGFR (mL/min/1.73 m^2)	64.1±18.7
D-dimer	1.15±5.49
Taking selective pulmonary vasodilators at baseline	48 (35.0)
mPAP (mmHg)	41.3±10.1
Cardiac index	2.53±0.59
PVR (wood unit)	8.62±4.27

Data are presented as mean±SD, median [interquartile range], or n (%). BNP, B-type natriuretic peptide; CRP, C-reactive protein; eGFR, estimated glomerular filtration rate; mPAP, mean pulmonary arterial pressure; PVR, pulmonary vascular resistance; WHO-FC, World Health Organization functional class.

CTEPH.[11] Therefore, the nutritional index in patients with CTEPH alone has not been established. Because CTEPH and PAH have different pathologies, comorbid diseases, and treatments,[18] an evaluation of patients with CTEPH is required.

The Controlling Nutritional Status (CONUT) score is a simple and well known nutritional indicator. It is calculated based on serum albumin concentration, total cholesterol concentration, and total lymphocyte count.[19] The CONUT score has been used to predict poor prognosis in heart failure,[6] coronary artery disease,[7] acute pulmonary embolism,[8] and PAH,[20] but not in CTEPH. Thus, the present study investigated the prognostic impact of the CONUT score in patients with CTEPH. We also evaluated the GNRI as a secondary factor.

Methods

Patients and Diagnosis

We retrospectively assessed the data of 157 stable CTEPH patients who underwent right heart catheterization at Nagoya University Hospital in the Tokai region of Japan between November 2006 and August 2021. Right heart catheterization was performed using a 6-Fr thermodilution catheter (Nipro Corporation, Osaka, Japan) to measure hemodynamic parameters such as mean pulmonary arterial pressure (mPAP), pulmonary artery wedge pressure (PAWP), and cardiac output (CO). PVR and the cardiac index were calculated as follows:

$$\text{PVR} = (\text{mPAP} - \text{PAWP}) / \text{CO}$$

$$\text{Cardiac index} = \text{CO} / \text{body surface area}$$

CTEPH was defined using the following criteria: (1) mPAP >20 mmHg and PAWP ≤15 mmHg at rest; and (2) chronic occlusion or stenosis due to residual thrombus after >3 months of anticoagulation therapy.[21]

Nutritional Assessment

The CONUT score at CTEPH diagnosis was calculated based on serum albumin concentration (g/dL), total cholesterol concentration (mg/dL), and total lymphocyte count (count/μL) as described previously.[19] The scores for each parameter were calculated as follows: (1) serum albumin score: 0 points for albumin ≥3.5 g/dL; 2 points for 3.0–3.4 g/dL; 4 points for 2.5–2.9 g/dL; and 6 points for albumin <2.5 g/dL; (2) total lymphocyte score: 0 points for lymphocyte count ≥1,600/μL; 1 point for 1,200–1,599/μL; 2 points for 800–1,199/μL; and 3 points for <800/μL; and (3) total cholesterol score: 0 points for cholesterol ≥180 mg/dL; 1 point for 140–179 mg/dL; 2 points for 100–139 mg/dL; and 3 points for <100 mg/dL.

The sum of these scores ranged from 0 to 12, with higher scores indicating worse nutrition; mild undernutrition, 2–4 points; moderate undernutrition, 5–8 points; and severe undernutrition, 9–12 points. The scores were assessed during the initial right heart catheterization for diagnosis.

The GNRI is also an indicator of nutritional risk, calculated using serum albumin concentration along with actual and ideal body weight values.[22] The GNRI was evaluated at baseline using the following formula:

$$14.89 \times \text{serum albumin (g/dL)} + 41.7 \times (\text{actual} / \text{ideal body weight})$$

Biomarker Analysis

Blood samples were collected at the time of right heart catheterization. The estimated glomerular filtration rate (eGFR) was determined using the formula from the Modification of Diet in Renal Disease study.[23]

Follow-up and Outcomes

The primary outcome was the 1-year rate of the primary composite outcome of all-cause death and non-elective hospitalization due to decompensated heart failure that met the following criteria: (1) hospitalization for 1 or more nights; and (2) requiring intravenous drug administration. The number of days from initial right heart catheterization to the event was recorded.

Ethics Statement

This study was conducted in accordance with the 1964 Declaration of Helsinki. The study protocol was approved by the Human Research Ethics Committee of Nagoya University Hospital (No. 2016-0438). All study participants provided written informed consent.

Statistical Analysis

Continuous variables were expressed as mean±SD and were compared using Welch's t-test. The B-type natriuretic peptide (BNP), C-reactive protein (CRP), and creatinine levels were expressed as median (first to third quartiles) and compared using the Mann-Whitney U test. Categorical variables were expressed as frequencies and percent-

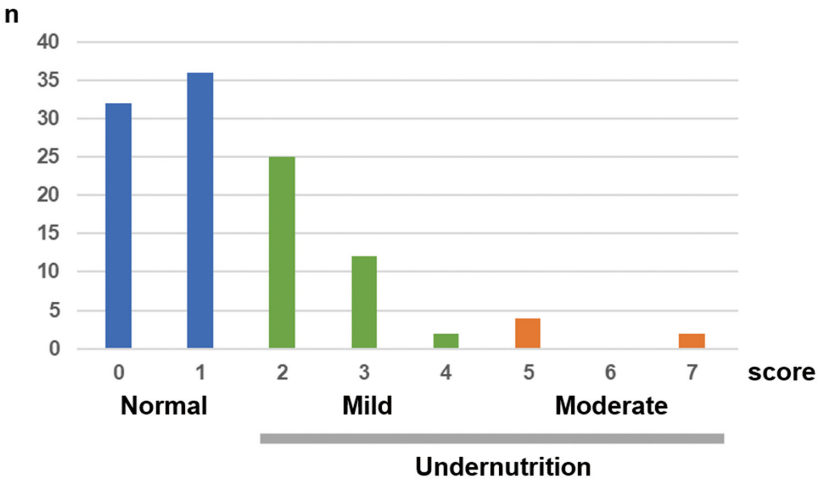

Figure 1. Nutritional status of study participants classified using the Controlling Nutritional Status score.

ages, and the chi-square test or Fisher's exact test was used to compare between groups. Receiver operating characteristic (ROC) curve analyses were conducted to determine cutoff values for the CONUT score to predict the primary outcomes. The optimal cutoff value was defined as the maximum Youden index. Patients were then divided into two groups according to the cutoff CONUT score. Kaplan-Meier analysis was performed to assess the times to the events. Differences in cumulative incidence between the two groups were compared using the log-rank test. Furthermore, Cox proportional hazards analysis was performed to evaluate the relationship between the CONUT score and the primary composite outcome. The hazards models were adjusted for potential confounding variables. Model 1 was adjusted for age and sex. Model 2 was adjusted for age, sex, World Health Organization Functional Classification (WHO-FC), and mPAP. Last, Model 3 was adjusted for potential confounding variables with a P value of <0.1 in the univariate analysis. The GNRI was analyzed the same way. Correlations among indices were analyzed using a linear regression model using Spearman's correlation test. The Statistical Package for the Social Sciences (version 29.0.0.0; IBM Corp., Armonk, NY, USA) was used for all statistical analyses. Statistical significance was defined as a P value <0.05.

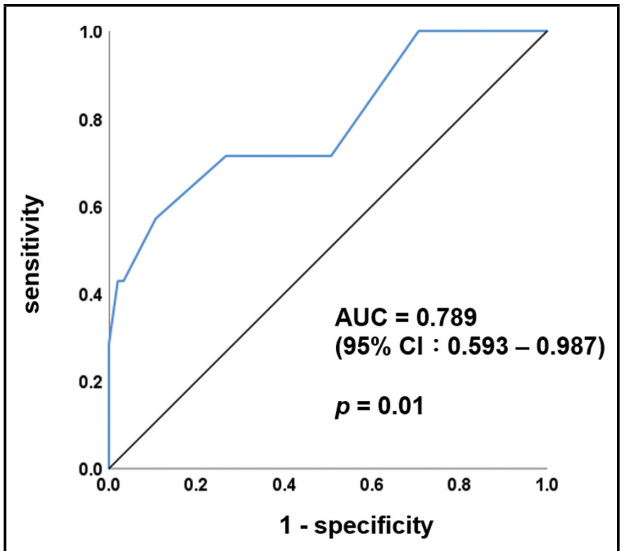

Figure 2. Receiver operating characteristic curve of the Controlling Nutritional Status score for the 1-year rate of primary outcomes of all-cause mortality and non-elective hospitalization due to heart failure. AUC, area under the curve; CI, confidence interval.

Results

The baseline characteristics of all 157 patients are presented in **Table 1**, and the distribution of CONUT scores is shown in **Figure 1**. At diagnosis of CTEPH, 51.6% (81/157) of the patients were undernourished, defined as a CONUT score ≥2 points.

ROC analysis determined the optimal cutoff value to be a CONUT score of 3.5 based on the maximum Youden index (area under the curve=0.789; 95% confidence interval [CI] 0.593–0.987; P=0.01; **Figure 2**).

Table 2 shows the baseline clinical characteristics of the study population, which was divided into 2 groups according to CONUT scores ≤3 (low CONUT group) and ≥4 (high CONUT group). Serum albumin, total cholesterol, and lymphocyte count, which are components of the CONUT score, were significantly lower in the high CONUT group. The high CONUT group also had a lower BMI, worse subjective symptoms based on WHO-FC, and higher BNP and CRP levels. Approximately one-third of the participants in both groups were taking selective pulmonary vasodilators at baseline. Furthermore, echocardiography, hemodynamic, pulmonary, and exercise tolerance assessments were similar between the high and low CONUT groups. The rates of invasive treatment during the follow-up period were comparable between the two groups.

The cumulative incidence of the primary outcome was 3 (2.2%) of 137 patients in the low CONUT group and 4 (20%) of 20 patients in the high CONUT group (**Table 3**). All-cause mortality was significantly higher in the high CONUT group than in the low CONUT group, with the causes of death including worsening of the underlying

Table 2. Patient Characteristics According to the Controlling Nutritional Status (CONUT) Score

	Low CONUT group (n=137)	High CONUT group (n=20)	P value
Age (years)	62.7±14.3	68.0±10.6	0.055
Female	88 (64.2)	13 (65.0)	0.947
Former smoker	43 (32.1)	9 (45.0)	0.255
Body mass index	24.3±4.7	22.1±3.9	0.030
WHO-FC			
I	1 (0.7)	1 (5.0)	<0.001
II	60 (43.8)	5 (25.0)	
III	72 (52.6)	9 (45.0)	
IV	4 (2.9)	5 (25.0)	
Albumin (g/dL)	3.9±0.3	3.3±0.4	<0.001
Total cholesterol (mg/dL)	190±35	151±25	<0.001
Lymphocytes (/μL)	1,725±699	1,170±423	<0.001
BNP (pg/mL)	57.3 [20.5–207.7]	246.2 [24.4–762.4]	0.035
CRP (mg/dL)	0.10 [0.06–0.22]	0.39 [0.05–1.21]	0.025
Creatinine (mg/dL)	0.78 [0.67–1.01]	0.86 [0.64–1.23]	0.368
eGFR (mL/min/1.73 m^2)	64.1±18.7	55.9±23.1	0.140
D-dimer	1.15±5.49	0.86±0.47	0.553
Comorbid conditions and medications			
Hypertension	44 (32.1)	9 (45.0)	0.255
Diabetes	16 (11.8)	4 (20.0)	0.304
Statin use	22 (16.1)	6 (30.0)	0.128
Cancer bearing	5 (3.6)	1 (5.0)	0.769
Undergoing chemotherapy	1 (0.7)	0	0.701
Steroid use	3 (2.2)	2 (10.0)	0.063
Taking selective pulmonary vasodilators at baseline	48 (35.0)	7 (35.0)	0.929
Anticoagulant			
Warfarin	54 (39.4)	10 (50.0)	0.633
Direct oral anticoagulant	82 (59.9)	10 (50.0)	
None	1 (0.7)	0	
Echocardiography data			
LVEF (%)	68.2±9.9	68.0±8.1	0.929
TAPSE (mm)	17.1±4.2	16.2±4.5	0.456
TRPG (mmHg)	63.3±23.7	64.8±18.7	0.750
Hemodynamics			
PAWP (mmHg)	9.3±4.1	10.0±3.3	0.372
mPAP (mmHg)	41.3±10.3	41.2±9.1	0.937
Cardiac index	2.53±0.59	2.49±0.58	0.808
PVR (wood unit)	8.60±4.35	8.77±3.80	0.861
Spirometry*			
%VC (%)	98.9±15.9	99.9±19.4	0.840
%FEV$_1$ (%)	87.9±18.0	92.2±15.7	0.309
%DL$_{CO}$	80.8±16.7	79.6±13.5	0.737
Exercise tolerance			
Peak $\dot{V}O_2$ (mL/min/kg)**	13.8±3.8	13.6±3.8	0.871
$\dot{V}E$ vs. $\dot{V}CO_2$ slope**	50.5±14.0	15.2±4.8	0.723
6MWD (m)***	373±98	368±115	0.883
Treatment during the follow-up period			
PEA	22 (16.1)	2 (10.0)	0.217
BPA	82 (59.9)	13 (65.0)	0.660
PEA+BPA	8 (5.8)	0	0.267

Data are presented as mean±SD, median [interquartile range], or n (%). *n=127 vs. n=16. **n=97 vs. n=10. ***n=101 vs. n=10. 6MWD, 6-minute walk distance; BPA, balloon pulmonary angioplasty; DL$_{CO}$, diffusing capacity of lung for carbon monoxide; FEV, forced expiratory volume; LVEF, left ventricular ejection fraction; PAWP, pulmonary artery wedge pressure; PEA, pulmonary endarterectomy; TAPSE, tricuspid annular plane systolic excursion; TRPG, tricuspid regurgitant pressure gradient; VC, vital capacity; $\dot{V}CO_2$, carbon dioxide production; $\dot{V}E$, minute ventilation; $\dot{V}O_2$, breath-by-breath oxygen consumption. Other abbreviations as in Table 1.

Table 3. Cumulative Incidence of All-Cause Mortality and Non-Elective Hospitalization Due to Heart Failure

	Low CONUT group (n=137)	High CONUT group (n=20)	P (log-rank)
Composite outcome	3 (2.2)	4 (20)	<0.001
All-cause mortality	2 (1.5)	3 (15)	0.001
Worsening of CTEPH	0	1	
Perioperative period of PEA	1	0	
Sepsis	1	1	
Unknown	0	1	
Non-elective hospitalization	1 (0.7)	1 (5)	0.112

Data are presented as n (%). CTEPH, chronic thromboembolic pulmonary hypertension. Other abbreviations as in Table 2.

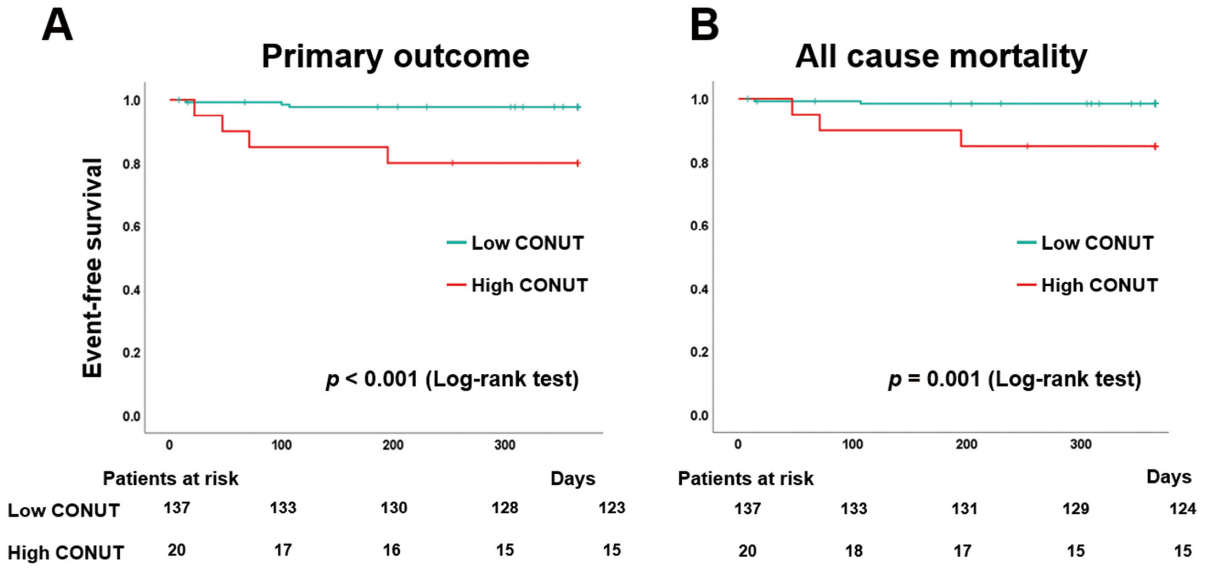

Figure 3. Kaplan-Meier curves of event-free survival rates in the low (score ≤3) and high (score ≥4) Controlling Nutritional Status (CONUT) score groups. Primary outcomes of non-elective hospitalization due to heart failure (**A**) and all-cause mortality (**B**).

CTEPH disease, perioperative PEA death, and sepsis. Kaplan-Meier analysis revealed that the primary composite outcome was significantly worse in the high CONUT group (log-rank P<0.001; **Figure 3A**). All-cause mortality was also significantly higher in the high CONUT group than in the low CONUT group (log-rank P=0.001; **Figure 3B**). Univariate Cox proportional hazards analysis revealed that the CONUT score, as per the point increase, was a significant predictor (**Table 4**). Multivariate Models revealed that the CONUT score per point increase was an independent risk factor for the primary outcome within 1 year (**Table 5**).

Evaluation of the GNRI found that it was not a significant predictive factor in COX analysis (**Supplementary Table 1**). The primary outcome was significantly correlated with the CONUT score, but not with the GNRI score (**Supplementary Table 2**).

Discussion

The present study highlighted the following points: (1) more than half of the patients with CTEPH were undernourished at diagnosis; and (2) the CONUT score at diagnosis was an independent predictor of all-cause mortality or non-elective hospitalization due to heart failure within 1 year in patients with CTEPH.

Several studies have reported an association between undernutrition and prognosis in patients with PAH.[9–12] Although a previous study evaluated the relationship between nutritional assessment and prognosis in patients with CTEPH, the study included only 48 patients with CTEPH, and the outcomes reported were for a mixture of patients with PAH and CTEPH.[11]

A report cited the prevalence of undernutrition at 21.1% in patients with PAH or CTEPH based on the GNRI.[11] In the present study, 51.6% of the patients with CTEPH were undernourished, as assessed using the CONUT score. The rates of malnutrition in other cardiovascular diseases also varied in previous studies, with 56.7% in acute pulmonary embolism[8] and 10.0–64.3% in heart failure.[6,24] The differences observed were due to the index used and the disease state. Malnutrition in patients with pulmonary hyperten-

Table 4. Univariate Cox Analysis of the Potential Confounding Variables Predicting for All-Cause Mortality or Non-Elective Hospitalization Due to Heart Failure Within 1 Year

	Univariate models		
	HR	95% CI	P value
CONUT per point	1.843	1.368–2.483	<0.001
Age (years)	1.065	0.983–1.154	0.126
Female gender	0.411	0.092–1.834	0.244
Hypertension	4.966	0.963–25.599	0.055
Diabetes	1.086	0.131–9.025	0.939
Smoking	1.944	0.392–9.631	0.416
Body mass index	0.315	0.038–2.613	0.284
WHO-FC	9.930	2.709–36.397	<0.001
TAPSE <15 mm	1.422	0.318–6.354	0.645
mPAP (mmHg)	1.068	1.000–1.139	0.049
Cardiac index	0.248	0.054–1.142	0.074
BNP per 100 (pg/mL)	1.171	1.065–1.287	0.001
eGFR <60 (mL/min/1.73 m^2)	7.478	0.900–62.113	0.063
CRP (mg/dL)	2.378	1.092–5.180	0.029

CI, confidence interval; HR, hazard ratio. Other abbreviations as in Tables 1,2.

Table 5. Multivariate Cox Analysis of the Predictive Value of the CONUT Score per Point Increase for All-Cause Mortality or Non-Elective Hospitalization Due to Heart Failure Within 1 Year

	HR	95% CI	P value
Model 1	1.741	1.288–2.354	<0.001
Model 2	1.761	1.137–2.727	0.011
Model 3	2.301	1.081–4.895	0.031

Model 1 was adjusted for age and sex. Model 2 was adjusted for age, sex, WHO-FC, and mPAP. Model 3 was adjusted for hypertension, WHO-FC, mPAP, cardiac index, BNP, eGFR, and CRP. Abbreviations as in Tables 1,2,4.

sion is caused by multiple factors, including appetite loss, malabsorption due to right heart failure, pharmacologic side-effects, and increased energy expenditure.[12,25] In the patients in the present study, we found similar hemodynamics, such as mPAP and PVR, between the high and low CONUT groups, although patients in the group with poorer nutritional status expressed worse symptoms based on WHO-FC. Similar results were reported in a previous PAH study.[12] In another study on PAH and CTEPH, hemodynamics and symptoms were similar regardless of nutritional status.[11] Worse symptoms in patients with poor nutritional status have been attributed to the influence of cachexia in heart failure.[26]

GNRI was previously reported as an independent predictor of poor outcome in patients with PAH or CTEPH.[11] GNRI is calculated using serum albumin level and BMI.[22] Although obesity is associated with a higher risk of all-cause mortality in the general population,[27] patients with cardiovascular disease concurrent with obesity or higher BMI have shown better outcomes,[15] which is described as the obesity paradox.[14] Several studies have reported a better prognosis in patients with PAH with a higher body weight,[16,17] whereas another study indicated that BMI was not associated with mortality.[10] Thus, the GNRI has no prognostic significance in some cardiovascular diseases because BMI is one of its components.[28] The GNRI was also not a significant predictor in the present study. In contrast, the CONUT score is not assessed using body weight or BMI.

The CONUT score is calculated using albumin, lymphocyte count, and total cholesterol.[19] Serum albumin is a well known marker of undernutrition and has historically been used to evaluate nutritional status.[29] However, a previous study indicated that albumin alone may be insufficient for nutritional assessment.[13] According to the Global Leadership Initiative on Malnutrition, albumin is not a nutritional evaluation criterion because it reflects inflammation rather than malnutrition in chronic inflammatory diseases.[30] A low lymphocyte count, a simple indicator of malnutrition,[31] can predict poor outcome in heart failure.[32] A low lymphocyte count also indicates systemic inflammation.[33] The pathophysiology of CTEPH is complex and mainly caused by proximal chronic obstruction by fibrotic clots and remodeling of the pulmonary arteries.[1,2] In addition, current concepts regarding the pathophysiology of CTEPH indicate that inflammation may influence the progression of CTEPH.[34,35] Chronic organized thrombi contain inflammatory cells such as lymphocytes and hemosiderin-laden macrophages.[36] Multiple macrophage subclusters and CD4+/CD8+ T cells, which contribute to chronic inflammation, have been identified in the pulmonary vascular cells of patients with CTEPH.[37] Right ventricular inflammation has been confirmed by magnetic resonance imaging in patients with CTEPH.[38] Furthermore, a low lymphocyte count can accelerate atherosclerosis in cardiovascular diseases.[33] Some patients with CTEPH present with atherosclerotic lesions in their pulmonary arteries.[39] Thus, the CONUT score may provide a good

estimation of chronic inflammation and atherosclerosis in CTEPH because of the indications of serum albumin and lymphocyte counts, thereby proving to be a good prognostic indicator.

Evidence on the prognostic significance of serum cholesterol level in patients with CTEPH is limited. A previous study found that the lower the high-density lipoprotein cholesterol (HDL-C) level, the bigger the right ventricular enlargement in CTEPH.[40] However, the present study found no correlation between HDL-C levels and prognosis. Cholesterol may reflect the disease severity of CTEPH,[40] but evaluating cholesterol alone is insufficient for predicting prognosis. Conversely, statin use affects total cholesterol, a component of the CONUT score. Previous studies concerning nutritional assessment in patients with heart failure included 34.0–39.4% under statin treatment.[24,41] In our study population, the rate of statin use was 17.8%, which is low. The lower rate of statin use among patients with CTEPH is another factor that highlights the prognostic value of the CONUT score.

Study Limitations

The present study has some limitations. First, this was a retrospective, single-center study that assessed a relatively small number of patients. Second, because of the development of treatments for CTEPH, clinical outcomes may be influenced by the time of enrollment. However, approximately 80% of our study population received invasive treatments, including PEA or BPA, which are considered appropriate treatments. Despite no statistical difference, PEA was less likely to be performed in the high CONUT group. Patients in the high CONUT group may be excluded from surgery because of poor general condition or may die before undergoing surgery. Third, long-term prognosis is difficult to assess. When extending the observation period with a median follow-up period of 1,064 days, patients with malnutrition evaluated using the CONUT score also had a higher incidence of all-cause mortality or non-elective hospitalization due to heart failure, whereas all-cause mortality was comparable (**Supplementary Figure**). However, the number of events and patients was too small in the present study to assess the long-term prognosis. Nutritional evaluation is considered an important indicator for short-term prognosis prediction because most events occur at an early stage in the malnutrition group. Last, the effect of nutritional intervention was not investigated. However, a study using a PAH mouse model demonstrated that nutritional intervention attenuated not only right ventricular thickness and fibrosis but also pulmonary congestion.[42] In the absence of evidence regarding nutritional intervention for CTEPH, further research is required to investigate the optimal management of undernutrition in patients with CTEPH.

Conclusions

The CONUT score is an effective tool for predicting the 1-year rates of all-cause mortality and non-elective hospitalization in patients with CTEPH. Patients with low CONUT scores had a relatively good prognosis, whereas those with high CONUT scores had poorer outcomes. Because the available evidence of undernutrition in CTEPH is limited, further studies in this field are recommended.

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Disclosures

T.M. is a member of *Circulation Reports*' Editorial Team. The other authors declare that there are no conflicts of interest.

IRB Information

The present study was approved by the Human Research Ethics Committee of Nagoya University Hospital (No. 2016-0438). All participants provided written informed consent.

Data Availability

The deidentified participant data will not be shared.

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Supplementary Files

Please find supplementary file(s);
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