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Prevalence and prognostic significance of malnutrition in patients with acute coronary syndrome treated with percutaneous coronary intervention

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The incidence and impact of malnutrition on acute coronary syndrome (ACS) remain unclear. This study aimed to evaluate the prevalence, clinical relevance, and prognostic outcomes of malnutrition in patients with ACS treated with percutaneous coronary intervention. This retrospective study included 1930 consecutive patients with ACS undergoing percutaneous coronary intervention and assessed their nutritional status using 3 scoring systems: Controlling Nutritional Status score, nutritional risk index (NRI), and prognostic nutritional index (PNI). The primary endpoint was all-cause mortality. The Controlling Nutritional Status, NRI, and PNI scores showed that 5.2%, 17.5%, and 3.9% of patients were moderately or severely malnourished, respectively. During a median follow-up of 67.2 months (interquartile range: 46.8–88.5 months), 74 (3.8%) patients died. Malnutrition was associated with a significantly increased risk for all-cause mortality compared with good nutrition (adjusted hazard ratios for moderate and severe malnutrition, respectively: 5.65 [95% confidence interval: 3.27–9.78] and 15.26 [7.50–31.05] for the NRI score, 5.53 [2.10–14.49] and 11.08 [5.69–21.59] for the PNI; $P < .001$). The current findings demonstrated that malnutrition is prevalent among patients with ACS and is closely associated with increased mortality. Further study is needed to evaluate the effects of nutritional interventions on the outcomes of patients with ACS.

Abbreviations: ACS = acute coronary syndrome, BMI = body mass index, CAD = coronary artery disease, CONUT = Controlling Nutritional Status, CV = cardiovascular, DES = drug-eluting stent, MACE = major cardiovascular event, MI = myocardial infarction, NRI = nutritional risk index, PCI = percutaneous coronary intervention, PNI = prognostic nutritional index, SD = standard deviation.

Keywords: coronary artery disease, malnutrition, mortality

1. Introduction

Acute coronary syndrome (ACS) is a major cause of death, showing a consistent increase in incidence despite treatment improvements, including percutaneous coronary intervention (PCI).[1] Thus, high-risk patients need to be identified according to their modifiable risk factors, with appropriate interventions being implemented to improve their prognosis.

Malnutrition is associated with poor prognosis in patients with ACS; thus, it represents an important modifiable risk factor compared with other risk factors. However, the effects of malnutrition on patients' prognosis have mainly focused on samples of patients with concomitant heart failure or renal failure[2,3]; however, there is a lack of research examining the effect of malnutrition on the outcomes of patients with ACS. Hence, this study evaluated the prevalence, clinical relevance, and prognostic effects of malnutrition in patients with ACS treated with PCI using 3 different scoring systems.

2. Methods

2.1. Study design and population

This retrospective observational study enrolled patients with ACS who consecutively underwent PCI with second-generation drug-eluting stents (DESs) at CHA Bundang Medical Center, Seongnam, Korea between August 2008 and December 2015. Exclusion criteria were: a history of coronary artery bypass graft surgery; a history of PCI; bifurcation lesions requiring side branch intervention; a mixture of different DES types; concomitant valvular or aortic surgery; cardiogenic shock; other comorbid conditions with a life expectancy of <12 months; and planned surgery necessitating the interruption of antiplatelet drug therapy within 6 postoperative months (Fig. S1, Supplemental Digital Content, http://links.lww.com/MD/G994). The final sample included 1930 patients. The study conformed to the principles of the Declaration of Helsinki and was approved by the Institutional Review Board of CHA Bundang

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Medical Center (approval number: CHAMC 2021-07-006). Considering the retrospective study design, the requirement for informed consent was waived.

2.2. Procedure and follow-up

PCI was performed according to the treatment guidelines at the discretion of the treating physician. As the study did not specify the PCI treatment type, the interventional cardiologists decided upon the application of predilatation, use of intravascular ultrasound, and selection of a specific DES type. Periprocedural anticoagulation was administered following a standard protocol.[4] All patients undergoing PCI received a loading dose of aspirin and adenosine diphosphate receptor antagonists before or during the intervention. After the procedure, aspirin was continued indefinitely and adenosine diphosphate receptor antagonists were prescribed for at least 6 to 12 months.[5] Treatment beyond this duration was provided at the physician's discretion. Specialized personnel collected data for all baseline characteristics and outcomes using a case report form.

2.3. Malnutrition screening tools

The patients' body mass index (BMI) was calculated by dividing the body mass (kg) by the square of the body height (m^2) and then classified into 4 groups: underweight (<18.5 kg/m^2), normal weight (18.5–22.9 kg/m^2), overweight (23.0–24.9 kg/m^2), and obesity (≥25 kg/m^2). This classification was based on the Asia-Pacific cutoff points.[6] Subsequently, malnutrition was screened using the 3 indices.

The Controlling Nutritional Status (CONUT) score developed by Ignacio de Ulíbarri[7] in 2005 is used to screen the nutritional status of hospitalized patients by cholesterol level, serum albumin, and total lymphocyte count. A score of 0 to 1 was considered normal, scores 2 to 4 mild, scores 5 to 8 moderate, and scores 9 to 12 severe malnutrition.

The nutritional risk index (NRI) can be easily calculated and predicts the prognosis of patients with various medical and surgical diseases,[8] and it is widely used owing to these advantages. NRI was originally defined by the following formula: 1.519 × serum albumin (g/L) + 41.7 × (current body weight [kg]/usual body weight [kg]). In previous studies, usual body weight was replaced with ideal body weight, which was calculated using the Lorenz formula: height (cm) – 100 – ([height (cm) – 150]/4) for men and height (cm) – 100 – ([height (cm) – 150]/2.5) for women.[9,10] When the participants' current body weight exceeded their ideal body weight, we set the weight as follows: current body weight/ideal body weight = 1.[9] As defined in previous studies, patients were divided into 4 nutritional risk categories according to their baseline NRI: no nutritional risk (NRI ≥ 100), mild nutritional risk (97.5 ≤ NRI < 100), moderate nutritional risk (83.5 ≤ NRI < 97.5), and severe nutritional risk (NRI < 83.5).[9,10]

The prognostic nutritional index (PNI) score was calculated using the formula: 0.005 × total lymphocyte count (mm^3) + 10 × serum albumin (g/dL).[8] Patients' scores were classified into 3 nutritional states: <35, severe malnutrition; 35 to 38, moderate nutrition; and >38, normal (NB: the PNI has no mild category).

2.4. Endpoints

The primary endpoint of the current study was all-cause mortality. The secondary endpoint was the composite of major cardiovascular events (MACEs), including cardiovascular (CV) death, myocardial infarction (MI), stroke, and repeat revascularization. Death was considered as cardiac unless an unequivocal noncardiac cause could be established. The protocol definition of MI was prespecified and was based on the universal definition of MI.[11] Stroke was identified by neurological deficits and confirmed by a neurologist using imaging modalities. Repeat revascularization included percutaneous or surgical revascularization procedures after index procedure, which was not planned at the time of index procedure. All clinical events were based on the treating physician's clinical diagnoses and determined by an independent group of clinicians using source documentation.

2.5. Statistical methods

Continuous data were expressed as means and standard deviation (SD), and categorical data as n (%). Differences between the groups were evaluated through analysis of variance for continuous variables and the χ^2 or Fisher exact test for categorical variables. The relationship among the 3 malnutritional indices was illustrated using Venn diagrams.

Time-to-event data were presented graphically using Kaplan–Meier curves. Survival rates between the groups were compared using log-rank tests. Cumulative events of the clinical outcomes were assessed using Kaplan–Meier estimates and compared using the log-rank test. We used Cox proportional hazards regression models to identify the predictors of all-cause mortality and MACEs. We also performed multivariate analyses using stepwise backward-elimination methods (retention threshold, $P < .05$) to assess the prognostic impact of malnutrition and adjust for potential confounders, including factors based on clinical plausibility or $P < .05$, in the univariate Cox analyses. The proportional hazards assumption was tested by examining log–log survival curves and partial Schoenfeld residuals, with no significant violations being found.

The malnutrition scores' discriminate ability in predicting all-cause mortality and MACEs was assessed and compared by calculating Harrell C-statistics, continuous net reclassification improvement, and integrated discrimination improvement. All analyses were 2-sided, with a significance level of $P < .05$. All statistical data were analyzed using SPSS (version 22.0; IBM Corp., Armonk, NY), and R (version 3.6.3 software; R Foundation for Statistical Computing, Vienna, Austria).

3. Results

3.1. Patient characteristics

Of the 1930 participants, 1012 (52.4%) had unstable angina, 433 (22.4%) and 485 (25.1%) had non-ST-segment elevation myocardial infarction and ST-segment elevation myocardial infarction, respectively. They had a mean age of 63.0 years (SD = 11.8), and two-thirds were men (67.9%, n = 1622). The mean left ventricular ejection fraction was 55.0% (SD = 13.6). Approximately half of the patients had multivessel coronary artery disease (CAD, 59.1%; n = 1141). In addition, 1265 (65.5%) patients underwent intravascular ultrasound, and 930 (48.2%) underwent complete revascularization. Most were obese (43.0%, n = 829), followed by 555 (28.8%), 506 (26.2%), and 40 (2.1%) patients with normal weight, overweight, and underweight, respectively. Table 1 summarizes the patients' demographic and clinical characteristics.

3.2. Prevalence of malnutrition, and relationship between malnutrition and BMI

The percentage of patients with malnutrition varied from 3.9% (n = 75; PNI) to 26.5% (n = 511; NRI) and 35.0% (n = 676; CONUT). Based on the CONUT and NRI scores, mild malnutrition was found in 575 (29.8%) and 174 (9.0%) patients, respectively. According to CONUT, NRI, and PNI calculations, 101 (5.3%), 337 (17.5%), and 75 (3.9%) patients had moderate-to-severe malnutrition, respectively (Table 2). Although the CONUT score was not significantly correlated with the NRI

Table 1

Demographic and clinical characteristics of the sample.

Variables	Total (N = 1930)
Demographic data	
Age, yr	63.0 ± 11.8
Male	1310 (67.9%)
Height, cm	163.0 ± 9.1
Weight, kg	65.6 ± 11.3
Body mass index, kg/m^2	24.6 ± 3.3
CV risk factors	
Hypertension	1121 (58.1%)
Diabetes mellitus	592 (30.7%)
Dyslipidemia	124 (6.4%)
Peripheral artery disease	8 (0.4%)
Chronic renal failure	84 (4.4%)
Heart failure	50 (2.6%)
Atrial fibrillation	50 (2.6%)
Stroke	120 (6.2%)
Chest pain presentation	
Unstable angina	1012 (52.4%)
NSTEMI	433 (22.4%)
STEMI	485 (25.1%)
Laboratory data	
Hemoglobin, g/dL	13.7 ± 3.1
Lymphocyte, ×10^6/L	2467.6 ± 1294.4
Albumin, g/dL	4.1 ± 0.5
Cholesterol, mg/dL	179.7 ± 45.4
Echocardiographic and angiographic data	
LV EF	55.0 ± 13.6
Extent of CAD	
1VD	789 (40.9%)
2VD	602 (31.2%)
3VD	539 (27.9%)
Use of IVUS	1265 (65.5%)
Complete revascularization	930 (48.2%)
Medical therapy	
Beta-blocker	988 (51.2%)
ACE inhibitor or ARB	1254 (65.0%)
Statin	1790 (92.7%)
Calcium channel blocker	604 (31.2%)
Malnutrition	
Any grade of malnutrition	
CONUT	676 (35.0%)
NRI	511 (26.5%)
PNI	75 (3.9%)
Moderate-to-severe malnutrition	
CONUT	101 (5.2%)
NRI	337 (17.5%)
PNI	75 (3.9%)

ACE = angiotensin-converting enzyme, ARB = angiotensin receptor blocker, CAD = coronary artery disease, CONUT = Controlling Nutritional Status, CV = cardiovascular, IVUS = intravascular ultrasound, LV EF = left ventricular ejection fraction, NRI = nutritional risk index, NSTEMI = non-ST-segment elevation myocardial infarction, PNI = prognostic nutritional index, STEMI = ST-segment elevation myocardial infarction, VD = vessel disease.

(r = –0.014, P = .543) or the PNI (r = –0.017, P = .468), the NRI and PNI scores were significantly correlated (r = 0.653, P < .001). Only 1.1% (n = 22) of the patients were classified as malnourished (any degree of malnutrition) on all 3 scales, while 48.2% (n = 930) were not malnourished on any scale (Fig. 1).

According to their CONUT scores, patients with malnutrition were more likely to be women and have diabetes mellitus than those who were not malnourished. Meanwhile, NRI and PNI scores that were categorized as malnutrition were more likely to be women, older, and have poorer renal function than those who were not malnourished, and they were more likely to have comorbidities including diabetes mellitus, peripheral artery disease, multivessel CAD, and reduced LV ejection fraction (Table S1A to S1C, Supplemental Digital Content, http://links.lww.com/MD/G995).

Malnutrition was most prevalent in patients with BMI < 18.5 kg/m^2 (Fig. 2; Table S2, Supplemental Digital Content, http://links.lww.com/MD/G995). In patients with BMI ≥ 18.5 kg/m^2, 34.9%, 25.3%, and 3.7% were malnourished according to the CONUT, NRI, and PNI scores, respectively. The rates of malnutrition were similar among the normal weight, overweight, and obese groups. Malnutrition was more prevalent in women than in men (38.4% vs 33.4%, 31.3% vs 24.2%, and 6.1% vs 2.8% for the CONUT, NRI, and PNI scores, respectively; P < .05 in all comparisons); there were no differences in its distribution by BMI categories according to sex (Table S3, Supplemental Digital Content, http://links.lww.com/MD/G995).

3.3. Malnutrition score, mortality, and cardiovascular outcomes

During a median follow-up of 67.2 (interquartile range: 46.8–88.5) months, 74 (3.8%) patients died, and 318 (16.5%) had MACEs. CV death, MI, stroke, and repeat vascularization accounted for 29 (1.5%), 18 (0.9%), 28 (1.5%), and 317 (16.4%), respectively. According to the NRI and PNI scores, the worsening nutritional status was associated with a significantly higher cumulative incidence of all-cause mortality and MACEs, but the CONUT score did not show a significant difference (Fig. 3).

The adjusted impacts of malnutrition on all-cause death and MACEs are summarized in Table 3 and Table S4 (Supplemental Digital Content, http://links.lww.com/MD/G995). When NRI and PNI indices were used, worsening malnutrition status was associated with higher risks of all-cause mortality, independent of whether the scores were used as a continuous or categorial variable. Worsening malnutrition status was associated with higher risks of MACEs regardless of the malnutrition index used, depending on whether the index was used as a continuous or categorical variable.

The NRI and PNI scores more accurately predicted mortality than the CONUT scores, but there were no significant differences among the 3 scores in predicting MACE, as seen in the discrimination index values in Table 4. However, the CONUT scores had a higher sensitivity for MACE than the NRI and PNI scores.

4. Discussion

In this study, malnutrition, defined by 3 different scoring systems, was prevalent in patients with ACS and was associated with a poor prognosis after adjustment for age, sex, intravascular ultrasound use, complete revascularization, medications, and other confounding factors. Although the 3 malnutrition indices differed in predicting clinical outcomes, they remained meaningful, considering that the variables used in score calculation could be easily obtained and malnutrition is a potentially modifiable risk factor and a therapeutic target.

According to the 3 malnutrition scores, the prevalence of malnutrition in the sample of participants with ACS varied from 3.9% to 35.0%. For example, the prevalence of moderate-to-severe malnutrition ranged from 3.9% to 17.5%. Although not all malnutrition indices were highly correlated with each other, only 1.1% of study patients were classified as malnourished (all degrees of malnutrition) and only 0.1% were classified as moderate-to-severe malnutrition by all 3 scores. Thus, the concordance between the scores for identifying more severe malnutrition was observed to be rather low, suggesting that these indices are not interchangeable. Most notably, the CONUT scores did not correlate with the other scores. The higher agreement between the NRI and PNI scores could be because of similarities in the variables used for calculation. Only a few studies have reported the prevalence of malnutrition in patients with ACS to date. A

Table 2

Prevalence of malnutrition according to 3 different scoring systems.

Nutritional index		Risk of malnutrition			
		Absent	Mild	Moderate	Severe
CONUT, points		0–1	2–4	5–8	9–12
Formula	Albumin, g/dL (score)	≥3.5 (0)	3.0–3.4 (2)	2.5–2.9 (4)	<2.5 (6)
	Total cholesterol, mg/dL (score)	≥180 (0)	140–179 (1)	100–139 (2)	<100 (3)
	Lymphocyte count/mm^3 (score)	≥1600 (0)	1200–1599 (1)	800–1199 (2)	<800 (3)
	Study population, n (%)	1254 (65.0)	575 (29.8)	86 (4.5)	15 (0.8)
NRI, points		≥100	97.50–99.99	83.50–97.47	<83.50
Formula		1.489 × serum albumin (g/L) + 41.7 × (weight in kilograms/ideal weight)			
	Study population, n (%)	1419 (73.5)	174 (9.0)	276 (14.3)	61 (3.2)
PNI score, points		>38	–	35–38	<35
Formula		10 × serum albumin (g/dL) + 0.005 × total lymphocyte count (mm^3)			
	Study population, n (%)	1855 (96.1)	–	28 (1.5)	47 (2.4)

CONUT = Controlling Nutritional Status, NRI = nutritional risk index, PNI = prognostic nutritional index.

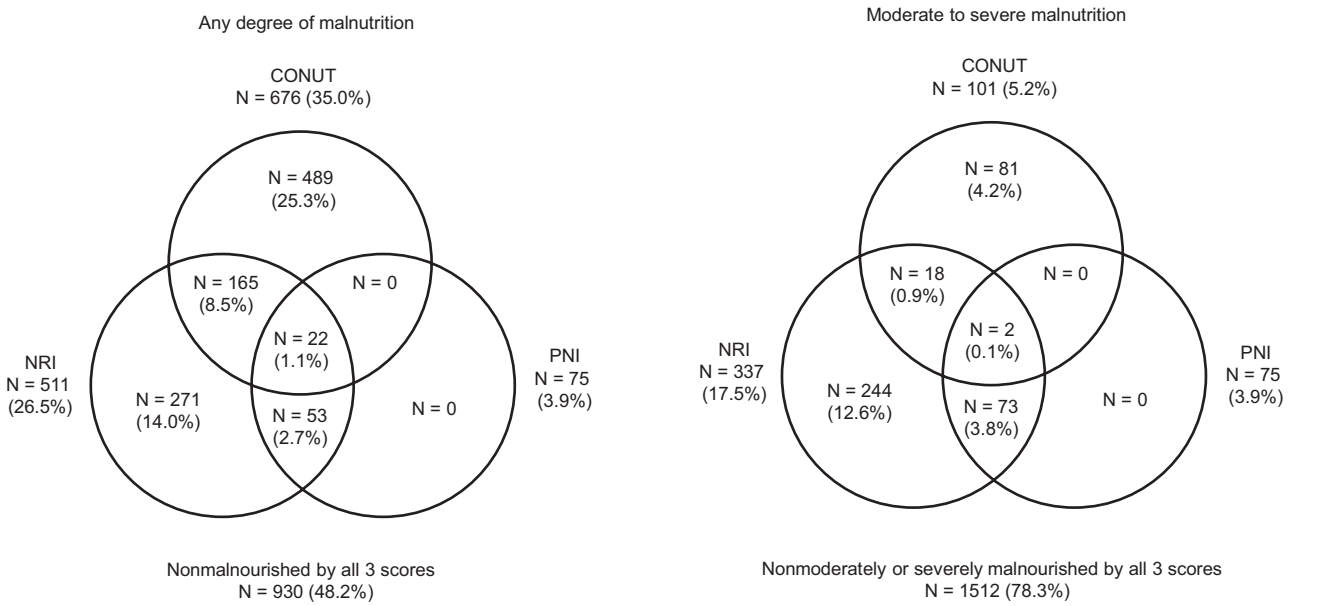

Figure 1. Prevalence of malnutrition according to 3 different scoring systems. CONUT = Controlling Nutritional Status, NRI = nutritional risk index, PNI = prognostic nutritional index.

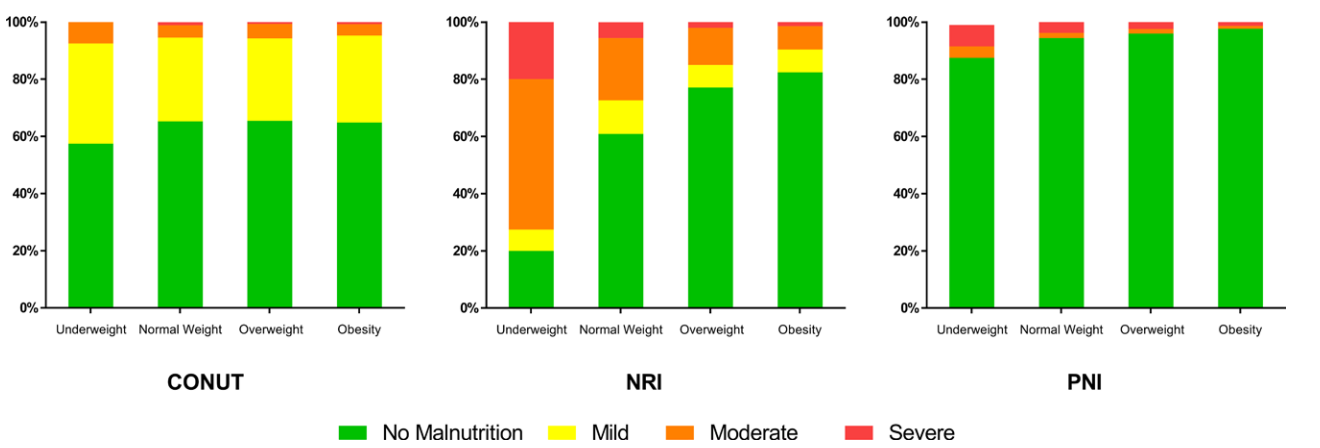

Figure 2. Percentage of malnutrition according to risk scores and body mass index. CONUT = Controlling Nutritional Status, NRI = nutritional risk index, PNI = prognostic nutritional index.

recent study using the Mini Nutritional Assessment Short Form found that 44% of patients with ACS were malnourished or at risk for malnutrition. Roubín et al[12] reported that 71.8% of ACS patients had mild malnutrition when classified according to the 3 scoring systems used in the current study. The proportion of patients with moderate-to-severe malnutrition was

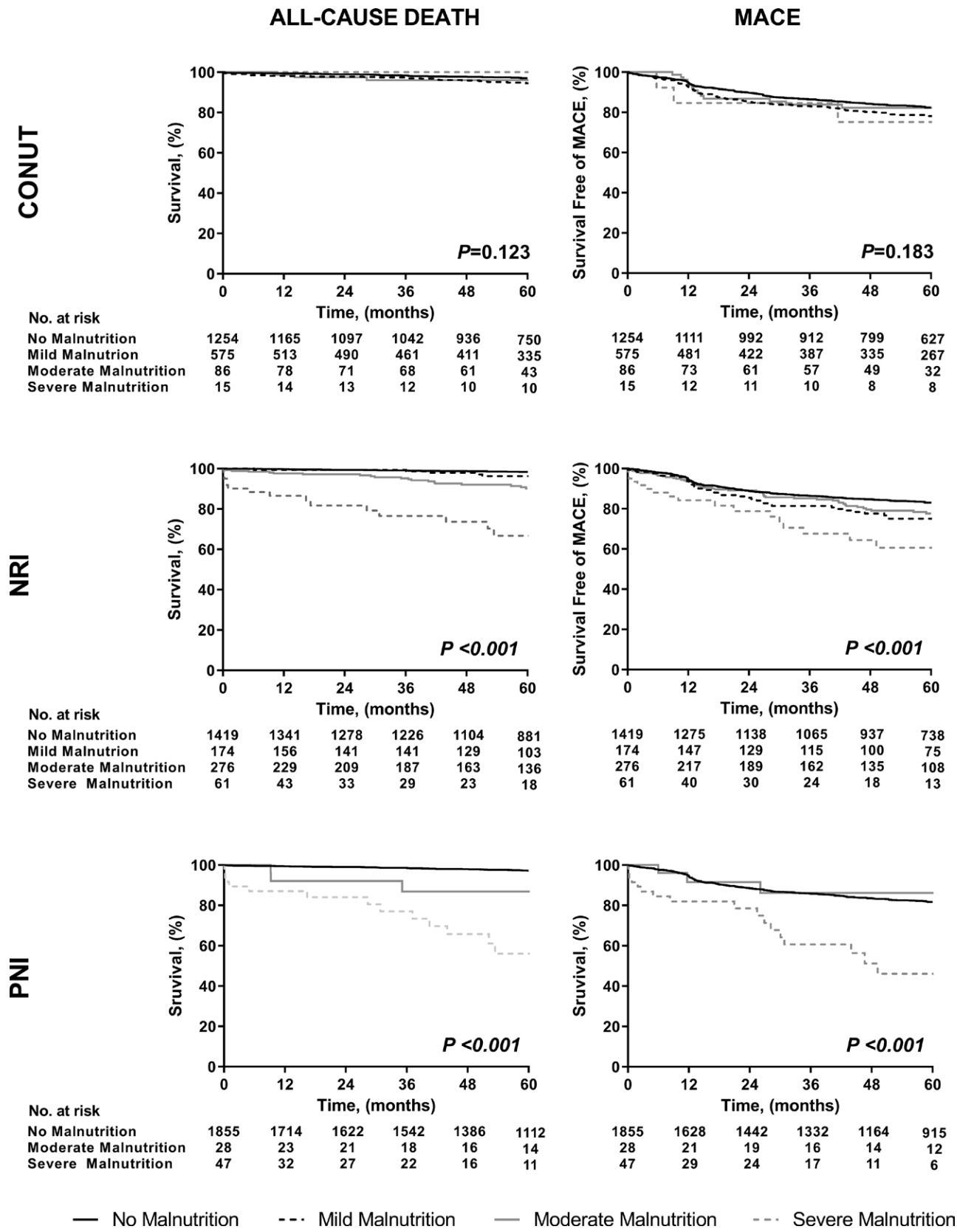

Figure 3. Malnutrition degrees and risk of mortality and major cardiovascular events. CONUT = Controlling Nutritional Status, NRI = nutritional risk index, PNI = prognostic nutritional index.

relatively low in this study compared to previous studies, which may have been influenced by the fact that the participants were mainly Asian and socioeconomic differences.

Malnutrition was found to be common in overweight and obese patients with ACS. For adults, the World Health Organization defines overweight and obesity as BMI ≥ 25 kg/

Table 3

Cox proportional hazards analyses of 3 malnutrition indexes to predict all-cause mortality and MACEs.

	Multivariable analysis			
	Mortality		MACE	
	HR (95% CI)	*P* value	HR (95% CI)	*P* value
CONUT, continuous,	–*	–*	1.071 (1.009–1.136)	.023
CONUT, categorical				
Mild risk	–*	–*	1.397 (1.103–1.769)	.006
Moderate risk	–*	–*	1.035 (0.590–1.815)	.905
Severe risk	–*	–*	1.303 (0.414–4.104)	.651
NRI, continuous	0.896 (0.878–0.915)	<.001	–*	–*
NRI, categorical				
Mild risk	1.454 (0.557–3.799)	.445	1.422 (1.003–2.016)	.048
Moderate risk	5.650 (3.263–9.783)	<.001	1.090 (0.792–1.499)	.598
Severe risk	15.264 (7.503–31.051)	<.001	1.909 (1.150–3.151)	.011
PNI, continuous	0.892 (0.869–0.916)	<.001	–*	–*
PNI, categorical				
Moderate risk	5.527 (2.108–14.489)	<.001	0.644 (0.206–2.015)	.450
Severe risk	11.083 (5.689–21.590)	<.001	2.422 (1.475–3.979)	<.001

Adjusted by age, sex, hypertension, diabetes mellitus, a history of heart failure, a history of peripheral artery disease, atrial fibrillation, presentation of chest pain, chronic renal failure, extent of coronary artery disease, use of intravascular ultrasound, complete revascularization, beta-blockers, angiotensin-converting enzyme inhibitors or angiotensin receptor blockers, and statins.

CI = confidence interval, CONUT = Controlling Nutritional Status, HR = hazard ratio, MACE = major cardiovascular event, NRI = nutritional risk index, PNI = prognostic nutritional index.

*Not in the final multivariate model.

Table 4

Comparative analysis of the discrimination ability of each malnutrition score for all-cause mortality and MACE.

	Mortality		
Discrimination ability	**CONUT**	**NRI**	**PNI**
Sensitivity, %	75.7	82.4	64.9
Positive predictive value, %	4.50	7.60	9.74
C-statistics (95% CI)	0.58 (0.55–0.60)	0.79 (0.77–0.80)	0.74 (0.72–0.76)

	CONUT vs NRI		CONUT vs PNI		PNI vs NRI	
Comparison	**Difference**	***P* value**	**Difference**	***P* value**	**Difference**	***P* value**
C-statistic	0.211	<.001	0.168	<.001	0.043	.114
cNRI	–0.098	<.001	–0.079	<.001	0.019	.279
IDI	–0.358	.020	–0.263	.030	0.198	.129

	MACE		
Discrimination ability	**CONUT**	**NRI**	**PNI**
Sensitivity, %	69.8	32.7	34.3
Positive predictive value, %	18.0	20.0	19.3
C-statistics (95% CI)	0.54 (0.52–0.56)	0.52 (0.50–0.54)	0.51 (0.48–0.53)

	CONUT vs NRI		CONUT vs PNI		PNI vs NRI	
Comparison	**Difference**	***P* value**	**Difference**	***P* value**	**Difference**	***P* value**
C-statistic	0.022	.382	0.035	.158	0.013	.382
cNRI	–0.006	.428	0.001	.886	0.007	.109
IDI	0.039	.587	0.025	.796	0.053	.836

CI = confidence interval, cNRI = continuous net reclassification improvement, CONUT = Controlling Nutritional Status, IDI = integrated discrimination improvement, MACE = major cardiovascular event, NRI = nutritional risk index, PNI = prognostic nutritional index.

m^2 and BMI ≥ 30 kg/m^2, respectively. However, these 2 classifications are defined differently in the Asia-Pacific region, in which BMI ≥ 23 kg/m^2 and BMI ≥ 25 kg/m^2 are classified as overweight and obesity, respectively; our study was conducted according to these criteria. In our study, a considerable number of overweight and obese patients were malnourished (CONUT: 34.9%; NRI: 19.6%), similar to previous studies. When analyzed by dividing patients with overweight and obesity into male and female groups, the proportion of malnourished patients showed a similar distribution. In a study of Western people with ACS, according to CONUT and NRI, half of the patients with a BMI ≥ 25 kg/m^2 were identified as having malnutrition.[13] A study on heart failure also reported that approximately half of the patients with obesity were malnourished according to CONUT.[2] Thus, being overweight or obese does not imply good nutrition in patients with ACS. Therefore, the nutritional status of patients with ACS should be evaluated, and measures should be taken regardless of BMI.

Malnutrition was associated with clinical outcomes. After adjusting for clinical variables, coronary revascularization, and medical treatment, malnutrition continued to be significantly associated with poor clinical outcomes, consistent with

recent studies. Malnutrition, defined by the Mini Nutritional Assessment Short Form, has been identified as an independent risk factor for all-cause mortality in geriatric patients with ACS, and malnutrition by geriatric NRI was associated with poor hospital outcomes and complications.[13,14] Chronic inflammatory disease has been related to increased muscle catabolism, cytokine production, decreased appetite, and lower albumin levels, and a poor nutritional status might be an alternative marker of inflammation in patients with CAD.[15,16] In addition, a high degree of malnutrition is associated with a high level of inflammation, reflecting a high atherosclerotic burden. The association between malnutrition and atherosclerosis refers to malnutrition-inflammation-atherosclerosis syndrome, possibly explaining the relationship between malnutrition and poor clinical outcomes in patients with CAD.[17]

Although the 3 malnutrition systems have been associated with poor clinical outcomes, our study showed that NRI and PNI scores were associated with the greatest predictive ability for all-cause mortality. The CONUT includes total lymphocyte count, total cholesterol levels, and serum albumin for assessing nutritional status, whereas the NRI and PNI include only albumin and weight. There were no significant differences in the CONUT scores for the 3 laboratory variables, namely, lymphocytes, total cholesterol, and albumin. Serum albumin is affected by many factors, especially in the acute phase. This study included patients with ACS, and changes in serum albumin in the acute phase may have affected the nutritional index in these patients. However, the overweight and obesity BMI groups had significantly higher values than the underweight and normal weight groups. Since high cholesterol levels were associated with poor clinical outcomes in patients with CAD, the lack of differences in cholesterol levels by CONUT grade may be unusual. One possibility may be that the effects of hyperlipidemia are overshadowed by the presence of stronger competitive risk factors for mortality.[18] Unlike PNI and CONUT, the NRI includes variables for weight and height for the ideal body weight calculation. Previous epidemiologic studies have reported that the incidence of CV events and mortality were significantly higher in patients who were underweight than those with normal weight or obesity after PCI.[19–21] This relationship has been referred to as reverse causation, given that these patients have an increased likelihood of being underweight from malnutrition or cachexia.

Our results suggest that patients with ACS undergoing PCI should be assessed for malnutrition, which may improve risk stratification and be helpful for secondary prophylaxis. Although malnutrition is a readily calculable indicator, systematic malnutrition screening is often overlooked. Screening patients with ACS for malnutrition might help identify individuals at high risk for poor clinical outcomes and might benefit from adapted secondary prevention programs that include nutritional supplements to improve clinical outcomes.[22,23] Malnutrition prevention is critical to avoid nutritional status deterioration and the overall health of patients with ACS. Additional well-designed studies evaluating the effects of the nutritional index at multiple points or the effects of nutritional interventions at multiple centers are needed to improve the efficacy of nutritional index and clinical outcomes.

This study has some limitations that need to be acknowledged. First, the single-center and retrospective nature of the study design had disadvantages, and PCI was performed at the discretion of attending physician. Therefore, there is a potential for selection bias. Second, the data were limited. For example, the current study did not include information about educational attainment that could help identify the causes of malnutrition or the socioeconomic characteristics that could contribute to malnutrition. The validity of the nutritional status evaluated by simple screening tools, such as the CONUT score, NRI, or PNI, remains undetermined because of the lack of comparison with comprehensive nutritional assessment, such as the Subjective Global Assessment and Mini Nutritional Assessment. Third, nutritional assessments were performed only at the time of PCI; therefore, the relationships between nutritional status changes over time and clinical outcomes have not been investigated. We did not evaluate the association of malnutrition scores with inflammatory markers or with body composition. Fourth, most patients in our registry were Asian and BMI was classified based on the Asia-Pacific cutoff points; therefore, it remains uncertain whether these findings can be generalized to other ethnic or social groups with different patient and procedural characteristics.

In conclusion, screening for malnutrition in patients with ACS treated with PCI facilitates the identification of those who are highly at risk for all-cause mortality and poor clinical outcomes. Nutritional support and tailored management are required to improve the prognosis of these patients.

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Supervision: Dong-Hun Cha, Sang-Wook Lim, Won-Jang Kim.
Visualization: Jung-Hoon Sung, Se Hun Kang.
Writing – original draft: Se Hun Kang.
Writing – review & editing: Se Hun Kang, Won-Jang Kim.

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