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Original Article

Prevalence of malnutrition in patients with acute coronary syndrome undergoing coronary angiography in Thailand: A retrospective observational study

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Abstract

Malnutrition is an important prognostic factor in patients with acute coronary syndrome (ACS), but it remains under-recognized in routine practice, particularly in Thailand, where local data are limited, and no population-specific nutritional screening tool has been validated. The Prognostic Nutritional Index (PNI) and Nutritional Risk Index (NRI) have been associated with mortality and major adverse cardiovascular events (MACEs) in patients with ACS, but their clinical usefulness in Thai patients remains unclear. This study aimed to determine the prevalence of malnutrition among patients with ACS undergoing coronary angiography (CAG) at Rajavithi Hospital, Bangkok, Thailand, and to assess the clinical usefulness of PNI and NRI in this setting. The secondary objective was to evaluate 1-year all-cause mortality and the occurrence of MACEs according to nutritional status. This study included 244 adult patients with ACS who were admitted between January 2023 and December 2024, underwent CAG, and completed a 1-year follow-up. Nutritional status was assessed using PNI and NRI, and categorized as severe, moderate, or no malnutrition. The primary outcome was 1-year all-cause mortality, while the secondary outcome was MACEs, defined as a composite of cardiovascular death, non-fatal myocardial infarction, non-fatal ischemic stroke, hospitalization for heart failure, and hospitalization for unstable angina. Associations between nutritional status and outcomes were examined using logistic regression. According to PNI, 43.8% of patients were malnourished, including 27.0% with severe malnutrition and 16.8% with moderate malnutrition. In contrast, NRI classified 99.6% of patients as severely malnourished. The 1-year all-cause mortality rate was 28.3%, and the MACE rate was 28.7%. Based on PNI, severe and moderate malnutrition were associated with higher mortality than no malnutrition (62.1% and 31.7% vs 10.9%, respectively). Severe malnutrition was associated with 13.34-fold higher odds of death (odds ratio (OR) 13.34; 95%CI: 6.41–27.71), while moderate malnutrition was associated with 3.78-fold higher odds (OR 3.78; 95%CI: 1.61–8.82). Severe and moderate malnutrition were also associated with higher odds of MACEs (OR 2.65; 95%CI: 1.38–5.06 and OR 2.89; 95%CI: 1.36–6.11, respectively). Malnutrition was common among Thai patients with ACS undergoing CAG and was strongly associated with adverse 1-year outcomes. Compared with NRI, PNI provided more clinically meaningful stratification in this cohort. Although formal comparative performance analyses were not performed, PNI may be a practical tool for nutritional risk assessment in routine ACS care.

Keywords: Acute coronary syndrome, malnutrition, prognostic nutritional index, nutritional risk index, MACE

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Introduction

Acute coronary syndrome (ACS) remains a major cause of morbidity and mortality in Thailand. Data from the Thai Registry in Acute Coronary Syndrome (TRACS) showed that the 1-year mortality rate remains substantial, ranging from 14% to 25% despite advances in diagnosis and treatment [1-3]. Although national management strategies in Thailand have continued to evolve, as reflected in the Thai Acute Coronary Syndrome Guidelines 2022 [3], long-term outcomes after ACS remain unsatisfactory for many patients [4-6]. In addition to established prognostic factors such as age, sex, and comorbidities, growing evidence has identified malnutrition as an important determinant of adverse outcomes in patients with ACS [7-13].

Malnutrition is increasingly recognized as a clinically relevant condition in cardiovascular disease because it reflects the combined effects of inadequate nutritional reserve, systemic inflammation, and metabolic stress. In patients with ACS, poor nutritional status may contribute to impaired recovery, increased vulnerability to complications, and a higher risk of mortality and major adverse cardiovascular events (MACEs). Accordingly, nutritional assessment has become an area of increasing interest in cardiovascular research and practice.

In Thailand, nutritional risk in hospitalized patients is commonly evaluated using the Nutritional Alert Form (NAF score), which incorporates questionnaire-based information, clinical history, and basic laboratory parameters. However, this tool was originally developed for use in general medical wards rather than for patients with ACS [14, 15]. Its applicability in ACS is therefore uncertain, particularly because many of these patients are classified as critically ill and may automatically be considered at least at moderate nutritional risk. In addition, the NAF score relies substantially on body weight and short-term weight change over the previous four weeks. In patients with cardiovascular disease, especially those with concomitant heart failure, these weight-based parameters may be distorted by fluid overload, potentially leading to overestimation of body mass and misclassification of nutritional status. These limitations highlight the need for more objective and context-appropriate approaches to nutritional assessment in patients with ACS.

Among the available objective nutritional indices, the Prognostic Nutritional Index (PNI) and the Nutritional Risk Index (NRI) have received particular attention. Both tools have been associated with mortality and MACEs in patients with ACS and other cardiovascular conditions [7-10, 16-18]. The PNI is derived from serum albumin and lymphocyte count, whereas the NRI incorporates serum albumin and the ratio of current to ideal body weight. These indices are simple to calculate and can routinely use available clinical data, making them potentially practical for bedside application. Nevertheless, their performance and suitability may vary across populations and clinical settings.

Despite the growing international literature, data on malnutrition in Thai patients with ACS remain limited. In particular, little is known about the prevalence of malnutrition in Thai patients undergoing coronary angiography (CAG), the relationship between nutritional status and subsequent clinical outcomes, and the most suitable nutritional assessment tool for this population [11, 19]. Therefore, this study aimed to determine the prevalence of malnutrition among patients with ACS undergoing CAG at Rajavithi Hospital in Bangkok, Thailand, and to assess which nutritional assessment tool is more clinically suitable in this setting. The secondary objective was to evaluate 1-year all-cause mortality and the occurrence of MACEs among malnourished patients with ACS treated at this center.

Methods

Study design and setting

This retrospective observational study was conducted at Rajavithi Hospital, a tertiary care center in Thailand. The study included patients admitted with ACS between January 2023 and December 2024 who underwent CAG. The study was designed to determine the prevalence of malnutrition in this population and to examine its association with 1-year all-cause mortality and MACEs. The protocol was approved by the Ethics Committee of Rajavithi Hospital, and all study procedures were conducted in accordance with the Declaration of Helsinki.

Sample and criteria

The study population consisted of adult patients aged ≥18 years who were admitted with a diagnosis of ACS and underwent CAG during the study period. The diagnosis of ACS was established according to the Thai Acute Coronary Syndrome Guidelines 2020 [2] and included ST-segment elevation myocardial infarction (STEMI), non-ST-segment elevation myocardial infarction (NSTEMI), and unstable angina. Patients were eligible for inclusion if complete clinical and laboratory data required for nutritional assessment were available and if follow-up data were obtained for at least 12 months. Patients were excluded if the duration of follow-up was less than 12 months or if essential clinical or laboratory information was missing.

Sample size and sampling method

The required minimum sample size was estimated using a standard formula for prevalence studies, assuming a malnutrition prevalence of approximately 30% among patients with ACS based on a previous report [6]. On this basis, the minimum required sample size was 225 patients. During the study period, all eligible consecutive patients who met the inclusion criteria were enrolled, yielding a total sample of 244 patients. A consecutive sampling approach was used to reduce selection bias and to better reflect routine clinical practice at this tertiary care center.

Study procedures

Baseline demographic, clinical, laboratory, echocardiographic, angiographic, and treatment data were retrieved from the medical records of eligible patients. Clinical presentation was categorized as STEMI, NSTEMI, or unstable angina. Laboratory data included complete blood count, serum albumin, serum creatinine, and lipid profile. Left ventricular systolic function was assessed by transthoracic echocardiography, and reduced systolic function was defined as a left ventricular ejection fraction (LVEF) of <40%.

CAG was performed in all included patients to evaluate coronary anatomy, including the presence of left main coronary artery disease and multivessel disease. Information on treatment strategy was also collected, including medical therapy and coronary revascularization. Pharmacological treatment included beta-blockers, renin–angiotensin–aldosterone system inhibitors, high-intensity statins, colchicine, and antiplatelet or anticoagulant therapy prescribed according to current guideline-directed management. Decisions regarding coronary revascularization followed the Thai Acute Coronary Syndrome Guidelines 2022 [3]. Complete revascularization was defined as treatment of all significant coronary lesions by percutaneous coronary intervention, coronary artery bypass grafting, or both, whereas incomplete revascularization was defined as the presence of at least one untreated significant lesion.

Study variables and measurements

Baseline variables included demographic characteristics, cardiovascular risk factors and comorbidities, laboratory parameters, echocardiographic findings, angiographic characteristics, and treatment variables. Nutritional status was assessed using the PNI, NRI, and body mass index (BMI).

PNI was calculated as 10 × serum albumin (g/dL) + 0.005 × total lymphocyte count (per mm^3) [16]. Based on the calculated score, patients were categorized as having severe malnutrition (PNI<35), moderate malnutrition (PNI 35–38), or no malnutrition (PNI>38) [16].

NRI was calculated as 1.519 × serum albumin (g/L) + 41.7 × (current body weight/ideal body weight) [16]. Ideal body weight was estimated using the Lorenz formula [16]. Nutritional status according to NRI was categorized as severe malnutrition (NRI<83.5), moderate malnutrition (NRI 83.5–97.5), or no malnutrition (NRI>97.5) [7, 9-10].

BMI was calculated as weight in kilograms divided by height in meters squared and was classified as underweight (<18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), or obese (≥30.0 kg/m^2) [16].

Study outcomes

The primary outcome of this study was 1-year all-cause mortality. The secondary outcome was the occurrence of MACEs during the 1-year follow-up period. MACEs were defined as a composite of cardiovascular death, non-fatal myocardial infarction, non-fatal ischemic stroke, hospitalization for heart failure, and hospitalization for unstable angina.

Statistical analysis

Categorical variables are presented as frequencies and percentages, whereas continuous variables are expressed as mean ± standard deviation (SD) or median with minimum and maximum values, as appropriate for the data distribution. Comparisons of categorical variables, including sex, comorbidities, ACS subtype, 1-year all-cause mortality, and MACEs, across nutritional status categories were performed using the Chi-square test or Fisher's exact test, as appropriate. Comparisons of continuous variables, such as age, BMI, and laboratory parameters, were conducted using one-way analysis of variance (ANOVA) for normally distributed data or the Kruskal–Wallis test for non-normally distributed data.

To evaluate the association between malnutrition status and clinical outcomes, univariable binary logistic regression analyses were performed, with nutritional status defined by PNI and NRI as independent variables and 1-year all-cause mortality and MACEs as dependent variables. The results are presented as odds ratios (ORs) with 95% confidence intervals (95%CI). All tests were two-sided, and $p<0.05$ was considered statistically significant.

Results

Patients' characteristics

A total of 244 patients with ACS who underwent CAG were included in this study, and their detailed baseline characteristics are presented in **Table 1**. The mean age was 65.9±12.8 years, and 58.2% were male. Based on BMI, most patients had normal weight (50.8%), followed by overweight (30.7%), obesity (10.2%), and underweight (8.2%). The most common comorbidities were hypertension (58.6%), dyslipidemia (42.6%), and diabetes mellitus (40.2%). Regarding ACS subtype, 59.0% of patients had NSTEMI and 41.0% had STEMI, while no eligible patients with unstable angina underwent CAG during the study period (**Table 1**).

In terms of cardiac and angiographic findings, 26.5% of patients had reduced left ventricular systolic function (LVEF<40%), and 70.5% had left main coronary artery disease or multivessel disease (**Table 1**). Complete revascularization was achieved in 76.0% of patients, whereas 13.6% underwent incomplete revascularization and 10.3% had non-significant coronary artery stenosis. Most patients received guideline-directed medical therapy, including dual antiplatelet therapy (89.3%) and high-potency statins (82.2%) (**Table 1**).

Prevalence of malnutrition among patients with ACS undergoing coronary angiography (CAG)

The prevalence of malnutrition varied markedly according to the nutritional assessment tool used, and detailed distributions of PNI and NRI categories are presented in **Table 1**. Based on the PNI, 43.8% of patients were classified as malnourished, comprising 27.0% with severe malnutrition and 16.8% with moderate malnutrition, while 56.1% were classified as having no malnutrition. In contrast, the NRI classified 99.6% of patients as having severe malnutrition and only 0.4% as having moderate malnutrition, with no patients categorized as having normal nutritional status (**Table 1**). These findings indicate that PNI provided greater differentiation of nutritional status in this cohort, whereas NRI showed very limited discriminatory ability.

Suitability of nutritional assessment tools

The suitability of the nutritional assessment tools differed markedly in this cohort. PNI classified patients into distinct nutritional categories, with 27.0% categorized as severe malnutrition, 16.8% as moderate malnutrition, and 56.1% as having normal nutritional status (**Table 1**). In contrast, NRI classified 99.6% of patients as having severe malnutrition and only 0.4% as having moderate malnutrition, with no patients identified as having normal nutritional status (**Table 1**).

Table 1. Baseline characteristics of ACS patients undergoing coronary angiography and their prevalence of malnutrition (n=244)

Characteristics	Frequency	Percentage
Sex		
Male	142	58.2
Female	102	41.8
Age (years)		
<50	26	10.7

Characteristics	Frequency	Percentage
50–59	48	19.7
60–69	69	28.3
70–79	69	28.3
≥80	32	13.1
Mean±SD	65.86±12.77	
Height (cm) mean±SD	161.05±8.87	
Weight (kg) mean±SD	63.42±14.16	
Body mass index (BMI) (kg/m²) mean±SD		
Underweight (<18.5)	20	8.2
Normal weight (18.5–24.9)	124	50.8
Overweight (25.0–29.9)	75	30.7
Obese (≥30.0)	25	10.2
Mean±SD	24.34±4.62	
Cardiovascular disease and comorbidities		
Hypertension	143	58.6
Diabetes mellitus	98	40.2
Dyslipidemia	104	42.6
Peripheral artery disease	7	2.9
Prior myocardial ischemia	54	22.1
Chronic heart failure	33	13.5
Atrial fibrillation	11	4.5
Chronic obstructive pulmonary disease (COPD)	5	2.0
Cancer	14	5.7
Acute coronary syndrome		
ST-segment elevation myocardial infarction (STEMI)	100	41.0
Non-ST-segment elevation myocardial infarction (NSTEMI)	144	59.0
Unstable angina	0	0
Laboratory data		
Creatinine (mg/dL) Mean±SD	1.96±2.20	
Hemoglobin (g/dL) Mean±SD	11.95±2.59	
Lymphocyte count (*10⁹/L) Mean±SD	10.17±4.33	
Albumin (g/dL) Mean±SD	3.76±0.63	
LDL (mg/dL) Mean±SD	122.04±53.95	
Echocardiographic and coronary angiographic finding		
Left ventricular ejection fraction (LVEF) <40%	62	26.5
LMCA/ multivessel disease (MVD)	172	70.5
Revascularization therapy revascularization		
Complete revascularization	184	76.0
Incomplete revascularization	33	13.6
Non-significant coronary artery stenosis	25	10.3
Medical therapy		
Antiplatelet		
None or single antiplatelet	11	4.5
Dual antiplatelet therapy	217	89.3
Triple/double therapy	15	6.2
Beta-blocker	146	60.6
Renin–angiotensin–aldosterone system (RAAS) inhibitor	88	36.5
High-potency statin	198	82.2
Colchicine	26	10.8
Prognostic Nutritional Index (PNI) score		
<35 (severe malnutrition)	66	27.0
35–38 (moderate malnutrition)	41	16.8
>38.0 (normal)	137	56.1
Mean±SD	37.64±6.25	
Nutritional Risk Index (NRI) score		
<83.5 (severe malnutrition)	243	99.6%
83.5–97.49 (moderate malnutrition)	1	0.4%
Mean±SD	51.39	±8.89

LMCA: left main coronary artery disease

This distribution indicated that PNI had better discriminatory ability and provided more clinically meaningful stratification of nutritional status than NRI in this study population. Therefore, the PNI nutritional classification was used for all further statistical analyses.

Associations of demographic and clinical characteristics with malnutrition

To better understand the factors associated with malnutrition among patients with ACS, the associations between demographic and clinical characteristics and malnutrition status, defined by the PNI classification, were analyzed. The results are presented in **Table 2**.

Table 2. Associations of demographic and clinical characteristics with malnutrition among ACS patients undergoing coronary angiography

Characteristics	Severe malnutrition (n=66)		Moderate malnutrition (n=41)		Normal (n=137)		Among groups (*p*-value)	Severe vs normal (*p*-value)	Moderate vs normal (*p*-value)	Severe vs moderate (*p*-value)
	n	%	n	%	n	%				
Sex							0.012*	0.221	0.003*	0.087
Male	37	56.1	16	39.0	89	65.0				
Female	29	43.9	25	61.0	48	35.0				
Age (years)							0.002*	<0.001*	0.073	0.504
<50	4	6.1	2	4.9	20	14.6				
50–59	7	10.6	9	22.0	32	23.4				
60–69	14	21.2	10	24.4	45	32.8				
70–79	27	40.9	12	29.3	30	21.9				
≥80	14	21.2	8	19.5	10	7.3				
Mean±SD	70.35±11.82		70.32±13.40		62.36±11.99		<0.001*	<0.001*	<0.001*	0.990
BMI (kg/m²)							0.006*	0.149	0.001*	0.083
<18.5	7	10.6	8	19.5	5	3.6				
18.5–24.9	34	51.5	23	56.1	67	48.9				
25.0–29.9	21	31.8	5	12.2	49	35.8				
≥30.0	4	6.1	5	12.2	16	11.7				
Mean±SD	23.57±4.50		23.34±5.36		25.01±4.35		0.007*	0.037*	0.041*	0.799
Cardiovascular disease and comorbidities										
Hypertension	47	71.2	21	51.2	75	54.7	0.048*	0.025*	0.691	0.037*
Diabetes mellitus	29	43.9	17	41.5	52	38.0	0.705			
Dyslipidemia	33	50.0	17	41.5	54	39.4	0.356			
Peripheral artery disease	2	3.0	3	7.5	2	1.5	0.105			
Prior myocardial ischemia	19	28.8	11	26.8	24	17.5	0.141			
Chronic heart failure	12	18.2	6	14.6	15	10.9	0.360			
Atrial fibrillation	5	7.6	4	9.8	2	1.5	0.015*	0.038*	0.026*	0.730
COPD	1	1.5	1	2.4	3	2.2	1.000			
Cancer	4	6.1	5	12.2	5	3.6	0.096	0.476	0.052	0.299
Acute coronary syndrome							0.087	0.375	0.029*	0.184
STEMI	26	39.4	11	26.8	63	46.0				
NSTEMI	40	60.6	30	73.2	74	54.0				
Echocardiographic and Coronary angiographic findings										
LVEF <40%	25	41.0	9	22.5	28	21.1	0.012*	0.004*	0.845	0.055
LMCA/MVD	48	72.7	28	68.3	96	70.1				
Treatment										
Complete revascularization	33	50.0	34	82.9	117	86.7	<0.001*	<0.001*	0.548	0.001*
Medical treatment										

Characteristics	Severe malnutrition (n=66)		Moderate malnutrition (n=41)		Normal (n=137)		Among groups (*p*-value)	Severe vs normal (*p*-value)	Moderate vs normal (*p*-value)	Severe vs moderate (*p*-value)
	n	%	n	%	n	%				
Antiplatelet							0.001*	0.004*	0.007*	0.074
None or single antiplatelet	7	10.8	0	0	4	2.9				
Dual antiplatelet therapy	52	80.0	35	85.4	130	94.9				
Triple/double therapy	6	9.2	6	14.6	3	2.2				
Beta-blocker	22	34.4	27	67.5	97	70.8	<0.001*	<0.001*	0.688	0.001*
RAAS inhibitor	12	18.8	12	30.0	64	46.7	<0.001*	<0.001*	0.060	0.185
High Potency Statin	41	64.1	34	85.0	123	89.8	<0.001*	<0.001*	0.401	0.021*
Colchicine	0	0	3	7.5	23	16.8	0.001*	<0.001*	0.144	0.054

BMI: body mass index; COPD: chronic obstructive pulmonary disease; LMCA: left main coronary artery disease; LVEF: left ventricular ejection fraction; MVD: multivessel disease; NRI: nutritional risk index; NSTEMI: non-ST-segment elevation myocardial infarction; PNI: prognostic nutritional index; RAASi: renin–angiotensin–aldosterone system inhibitor; STEMI: ST-segment elevation myocardial infarction.
* Statistically significant at $p<0.05$

Patients with severe and moderate malnutrition were older than those without malnutrition, with both malnourished groups showing significantly higher mean age than the normal group (overall $p<0.001$). Sex was also associated with nutritional status ($p=0.012$), with female patients being more frequent in the moderate malnutrition group than in the normal group.

Body mass index differed significantly across nutritional status categories ($p=0.006$), and mean BMI was lower in both severe and moderate malnutrition groups than in the normal group (**Table 2**). Hypertension ($p=0.048$) and atrial fibrillation ($p=0.015$) were also significantly associated with malnutrition status. In addition, reduced left ventricular ejection fraction (<40%) was more common in patients with severe malnutrition than in those without malnutrition (overall $p=0.012$) (**Table 2**).

Regarding treatment, complete revascularization was significantly less frequent in patients with malnutrition, particularly in the severe malnutrition group (overall $p<0.001$) (**Table 2**). The use of antiplatelet therapy ($p=0.001$), beta-blockers ($p<0.001$), renin–angiotensin–aldosterone system inhibitors ($p<0.001$), high-potency statins ($p<0.001$), and colchicine ($p=0.001$) also differed significantly across nutritional status categories (**Table 2**).

Rates of one-year all-cause mortality and major adverse cardiovascular events (MACEs)

During the 1-year follow-up period, 69 of 244 patients died, corresponding to an all-cause mortality rate of 28.3% (**Table 3**). During the 1-year follow-up, 70 of 244 patients (28.7%) experienced MACEs (**Table 3**). Cardiovascular death was the most frequent event, occurring in 17.2% of patients, followed by heart failure hospitalization (7.8%), non-fatal myocardial infarction (3.3%), non-fatal ischemic stroke (2.0%), and unstable angina hospitalization (0.8%) (**Table 3**).

Table 3. Rates of one-year all-cause mortality and MACEs among ACS patients undergoing coronary angiography

Outcome	Total (n=244)	
	Frequency	Percentage
All cause death at 1 year		
Yes	69	28.3
No	175	71.7
Major adverse cardiovascular events		
Yes	70	28.7
No	174	71.3
Cardiovascular death	42	17.2
Non-fatal myocardial ischemia	8	3.3
Non-fatal ischemic stroke	5	2.0
Heart failure	19	7.8
Unstable angina	2	0.8

Association of nutritional status with one-year all-cause mortality

Based on the PNI, the proportion of deaths increased with worsening nutritional status, as shown in **Table 4**. One-year all-cause mortality occurred in 62.1% of patients with severe malnutrition, 31.7% of those with moderate malnutrition, and 10.9% of those without malnutrition. The overall difference across nutritional status categories was statistically significant ($p<0.001$). Pairwise comparisons showed that both severe and moderate malnutrition were associated with significantly higher mortality than normal nutritional status ($p<0.001$ and $p=0.001$, respectively). In addition, mortality was significantly higher in patients with severe malnutrition than in those with moderate malnutrition ($p=0.002$) (**Table 4**).

In the univariable binary logistic regression analysis, severe malnutrition was associated with a 13.34-fold higher odds of 1-year all-cause mortality compared with no malnutrition (OR=13.34; 95%CI: 6.41–27.717; $p<0.001$), whereas moderate malnutrition was associated with 3.78-fold higher odds of mortality (OR=3.78; 95%CI: 1.61–8.82; $p=0.002$) (**Table 5**). In addition, when analyzed as a continuous variable, higher PNI was associated with lower odds of mortality (OR=0.81; 95%CI: 0.76–0.86; $p<0.001$) (**Table 5**). These findings indicate that poorer nutritional status, as assessed by PNI, was strongly associated with an increased risk of death within 1 year after ACS.

Table 4. Association between all-cause mortality and MACEs and malnutrition

Characteristic by PNI score	Severe malnutrition (n=66)		Moderate malnutrition (n=41)		Normal (n=137)		Among groups (*p*-value)	Severe vs normal (*p*-value)	Moderate vs normal (*p*-value)	Severe vs moderate (*p*-value)
	n	%	n	%	n	%				
All-cause death at 1 year							<0.001*	<0.001*	0.001*	0.002 [a]*
Yes	41	62.1	13	31.7	15	10.9				
No	25	37.9	28	68.3	122	89.1				
Major adverse cardiovascular events							0.002*	0.003*	0.005*	0.832 [a]
Yes	26	39.4	17	41.5	27	19.7				
No	40	60.6	24	58.5	110	80.3				
Cardiovascular death	20	30.3	9	22.0	13	9.5	0.001*	<0.001*	0.033*	0.345 [b]
Non-fatal myocardial ischemia	2	3.0	2	4.9	4	2.9	0.787			
Non-fatal ischemic stroke	0	0	1	2.4	4	2.9	0.453			
Heart failure	7	10.6	4	9.8	8	5.8	0.409			
Unstable angina	0	0	1	2.4	1	0.7	0.381			

[a] Analyzed with Chi-square test
[b] Analyzed with Fisher's exact test
* Statistically significant at $p<0.05$

Association of nutritional status with major adverse cardiovascular events (MACEs)

The proportion of MACEs was higher among malnourished patients based on PNI. MACEs occurred in 39.4% of patients with severe malnutrition and 41.5% of those with moderate malnutrition, compared with 19.7% of patients without malnutrition (**Table 4**). Both severe and moderate malnutrition were significantly associated with a higher proportion of MACEs than no malnutrition (p=0.003 and p=0.005, respectively) (**Table 4**).

In the univariable binary logistic regression analysis, severe malnutrition was associated with a 2.65-fold higher odds of MACEs compared with no malnutrition (OR=2.65; 95%CI: 1.38–5.06; p=0.003), while moderate malnutrition was associated with a 2.89-fold higher odds (OR=2.89; 95%CI: 1.36–6.11; p=0.006) (**Table 5**). When analyzed as a continuous variable, higher PNI was associated with lower odds of MACEs (OR=0.94; 95%CI: 0.90–0.98; p=0.009) (**Table 5**). These findings indicate that poorer nutritional status was associated with an increased risk of adverse cardiovascular outcomes during follow-up.

Table 5. Binary logistic regression analysis of PNI for predicting all-cause mortality and major adverse cardiovascular events (MACEs)

Variables	Mortality			Major adverse cardiovascular events		
	OR	95%CI	*p*-value	OR	95%CI	*p*-value
PNI, continuous	0.81	0.76–0.86	<0.001*	0.94	0.90–0.98	0.009*
PNI, categorical						
Severe malnutrition	13.34	6.41–27.71	<0.001*	2.65	1.38–5.06	0.003*
Moderate malnutrition	3.78	1.61–8.82	0.002*	2.89	1.36–6.11	0.006*
Normal	Ref					

* Statistically significant at p<0.05

Discussion

This study evaluated the prevalence of malnutrition and its prognostic significance in patients with ACS undergoing CAG using two nutritional assessment tools, namely the Prognostic PNI and NRI. Based on PNI, 43.8% of patients were classified as malnourished, including 27.0% with severe malnutrition and 16.8% with moderate malnutrition. Malnutrition defined by PNI was also strongly associated with adverse clinical outcomes, as both severe and moderate malnutrition were associated with higher 1-year all-cause mortality and MACEs. In contrast, NRI classified nearly all patients as severely malnourished, indicating poor discriminatory ability in this cohort. These findings suggest that malnutrition is common among Thai patients with ACS and that PNI may provide more clinically meaningful risk stratification in this setting [7-10].

The prevalence of malnutrition, as measured by PNI, in the present study is generally consistent with previous reports from international ACS cohorts [7-10]. This finding reinforces the growing recognition that malnutrition is not uncommon in patients with cardiovascular disease, particularly among older adults and those with multiple comorbidities. In the present study, malnutrition was significantly associated with older age, lower body mass index, hypertension, atrial fibrillation, reduced left ventricular ejection fraction, lower rates of complete revascularization, and less frequent use of several guideline-directed therapies. These findings suggest that malnutrition may cluster with a more vulnerable clinical profile in patients with ACS.

The strong association between PNI-defined malnutrition and adverse outcomes is biologically plausible. PNI is derived from serum albumin and total lymphocyte count, both of which reflect nutritional and inflammatory status. In patients with ACS, low serum albumin may indicate poor nutritional reserve, systemic inflammation, or both, whereas lymphopenia may reflect physiological stress, immune dysregulation, and catabolic burden [16-17,20-25]. Together, these abnormalities may identify patients with reduced physiological resilience who are less able to tolerate acute ischemic injury and its complications. This may explain why patients with severe malnutrition had markedly higher odds of 1-year mortality and MACEs than those without malnutrition [7-13].

Another important finding was the association between malnutrition and reduced left ventricular systolic function. Patients with severe malnutrition were more likely to have a left ventricular ejection fraction <40%, suggesting that impaired cardiac function may contribute to

worsening nutritional status. In patients with cardiovascular disease, reduced cardiac output may promote tissue hypoperfusion, neurohormonal activation, systemic inflammation, and increased resting energy expenditure, all of which may accelerate catabolism [20-22]. In addition, congestion-related gut edema may impair appetite and nutrient absorption, further aggravating nutritional decline. This interaction between cardiac dysfunction and malnutrition may partly explain the poor prognosis observed in malnourished patients in the present study.

Patients with malnutrition, particularly those with severe malnutrition, were also less likely to undergo complete revascularization and less likely to receive several guideline-directed medical therapies, including beta-blockers, renin–angiotensin–aldosterone system inhibitors, and high-potency statins. This pattern may reflect greater clinical instability, frailty, or early deterioration in malnourished patients, which may limit the use of invasive procedures and optimal pharmacological treatment. Therefore, malnutrition may not only represent an adverse biological condition but may also mark a subgroup of patients who are less likely to receive comprehensive ACS management. This may further contribute to the higher mortality and MACE rates observed in this group.

The overall 1-year mortality rate in this study was 28.3%, which appears higher than rates reported in some Thai and international ACS registries [1-3]. This may be explained by the higher-risk nature of the study population, as the present study was conducted in a tertiary care center and included a substantial proportion of patients with multivessel or left main coronary artery disease, reduced left ventricular ejection fraction, and multiple comorbidities. Such characteristics may indicate a population with more advanced disease and greater clinical complexity, which may reasonably contribute to poorer outcomes.

In contrast to PNI, NRI showed very limited discriminatory ability, as 99.6% of patients were classified as severely malnourished. This finding raises concerns regarding the applicability of NRI in Thai patients with ACS. NRI is calculated using serum albumin and the ratio of current body weight to ideal body weight. In ACS, especially in patients with concomitant heart failure, admission body weight may be influenced by fluid overload and may not accurately reflect actual nutritional status. As a result, NRI may overestimate the severity of malnutrition in this setting [9, 10]. In addition, the ideal body weight component of NRI was estimated using the Lorenz formula, which has not been formally validated in Thai populations. Differences in anthropometric characteristics may further limit the accuracy of this index. Taken together, these factors may explain the poor stratification performance of NRI in the present study [26,27].

From a clinical perspective, PNI appears to be more practical and informative for nutritional assessment in patients with ACS. It uses only serum albumin and lymphocyte count, both of which are routinely measured in hospitalized patients, and does not rely on body weight-based estimates that may be distorted in the acute cardiovascular setting. Because it is simple, objective, and readily available, PNI may be useful as an initial screening tool to identify patients at higher nutritional and prognostic risk. Early recognition of malnutrition may support more comprehensive patient evaluation and may help guide closer monitoring and multidisciplinary care in high-risk patients with ACS [7-10].

This study has several limitations. First, this was a single-center retrospective observational study conducted at a tertiary care hospital, which may limit the generalizability of the findings to other settings and to the broader Thai ACS population [1,19]. Second, the retrospective design limited the availability of detailed nutritional information, including dietary intake, formal nutritional assessments, and longitudinal nutritional changes over time. Third, body weight measured at admission may not have reflected dry weight in some patients, particularly those with fluid overload or heart failure, which may have affected the accuracy of BMI and NRI calculations. Fourth, formal comparative performance analyses between PNI and NRI, such as receiver operating characteristic curve analysis or area under the curve comparison, were not performed. Therefore, although PNI appeared to provide better clinical stratification in this cohort, definitive superiority cannot be concluded. Finally, the logistic regression analyses were univariable and did not adjust for potential confounders, such as age, left ventricular function, renal function, comorbidities, ACS subtype, and treatment strategy. Accordingly, the findings should be interpreted as associations rather than independent predictive effects.

Future studies should include prospective multicenter designs with more detailed nutritional data, serial anthropometric assessments, and formal comparisons between nutritional screening tools. Validation of ideal body weight formulae and nutritional cutoffs in Thai populations would also be important, particularly if NRI or other weight-based tools are to be used in cardiovascular settings. In addition, studies examining whether nutritional intervention can improve outcomes in high-risk malnourished patients with ACS would be of substantial clinical value [11,19].

Conclusion

This study is the first to report the prevalence and prognostic significance of malnutrition in Thai patients with acute coronary syndrome undergoing CAG using the PNI index as the primary nutritional assessment tool. The prevalence of malnutrition was 43.8% and was more frequently observed among patients with older age, hypertension, atrial fibrillation, and reduced left ventricular ejection fraction.

PNI was shown to be a simple and clinically useful tool for nutritional assessment and was clearly associated with clinical outcomes. Patients with severe malnutrition had 13.34-fold higher odds of 1-year all-cause mortality and 2.65-fold higher odds of MACEs than those without malnutrition, while patients with moderate malnutrition had 3.78-fold higher odds of mortality and 2.89-fold higher odds of MACEs. These findings support the potential value of integrating PNI-based nutritional assessment into routine care for patients with acute coronary syndrome to identify high-risk individuals and support more comprehensive cardiovascular management.

Ethics approval

The study was approved by the Institutional Review Board of Rajavithi Hospital (approval number:046/2022). Written informed consent was obtained from all participants.

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Competing interests

There were no identified potential conflicts of interest related to this article.

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Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

Declaration of artificial intelligence use

This study used artificial intelligence (AI) tool, ChatGPT, in the language refinement to improve grammar, sentence structure, and readability of the manuscript. We confirm that all AI-assisted processes were critically reviewed by the authors to ensure the integrity and reliability of the results.

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