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Relationship Between Nutritional Risk Indices and Severity of Coronary Artery Disease in Patients With Acute Coronary Syndrome

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Abstract

Background

Nutritional risk is increasingly recognized as an important but under-recognized factor associated with adverse cardiovascular status in patients with acute coronary syndrome (ACS). Lower nutritional reserve may reflect systemic inflammation, metabolic vulnerability, and greater coronary atherosclerotic burden.

Objective

This study aimed to evaluate the association between nutritional risk, assessed using the Nutritional Risk Index (NRI) and Geriatric NRI (GNRI), and angiographic severity of coronary artery disease (CAD), measured by the SYNTAX Score (SS), among patients with ACS.

Materials and methods

This cross-sectional study was conducted in the Department of Cardiology, Chittagong Medical College Hospital, Bangladesh, from April 2024 to March 2025. A total of 140 admitted patients with ACS who underwent coronary angiography during index hospitalization were enrolled through consecutive sampling. Nutritional status was assessed using the NRI for patients aged below 65 years and the GNRI for patients aged 65 years or above. Patients were categorized into no, low, and high nutritional risk groups. Angiographic severity was assessed using the SS and classified into low-, intermediate-, and high-risk categories.

Results

Among 140 patients, 61 (43.6%) had some degree of nutritional risk, including 32 (22.9%) with low nutritional risk and 29 (20.7%) with high nutritional risk. Patients with nutritional risk were older and had lower serum albumin levels than those without nutritional risk. Higher SS and a greater frequency of multivessel disease were observed among patients with low and high nutritional risk. NRI/GNRI scores demonstrated a significant moderate negative correlation with SS ($r_s = -0.513$, $p < 0.001$), indicating that lower nutritional index scores were associated with greater angiographic severity. Exploratory receiver operating characteristic (ROC) analysis suggested acceptable discriminatory ability of NRI/GNRI for identifying patients with high-risk SS. In multivariable linear regression analysis, NRI/GNRI score remained significantly negatively associated with SS after adjustment for demographic and clinical factors (B = −0.386, 95% confidence interval (CI): −0.624 to −0.149; p = 0.002). Smoking, dyslipidemia, and sex were also significantly associated with SS.

Conclusions

Nutritional risk was common among patients with ACS and was significantly associated with greater angiographic severity and complexity of CAD. NRI/GNRI may provide simple, low-cost measures for identifying patients with a greater coronary atherosclerotic burden. However, the exploratory ROC findings require further validation before these indices can be recommended for clinical risk stratification.

Categories: Nutrition, Cardiology, Internal Medicine
Keywords: acute coronary syndrome, coronary artery disease, geriatric nutritional risk index, nutritional risk, nutritional risk index, syntax score

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Introduction

Acute coronary syndrome (ACS) encompasses a spectrum of life-threatening clinical conditions that commonly arise from atherosclerotic plaque rupture or erosion, subsequent thrombus formation, and myocardial ischemia [1]. Despite substantial advances in pharmacological treatment, percutaneous coronary intervention (PCI), and surgical revascularization, ACS continues to contribute significantly to global cardiovascular morbidity and mortality [2]. Although conventional cardiovascular risk factors such as diabetes mellitus, hypertension, dyslipidemia, and smoking are well established, increasing attention has been directed toward malnutrition as a potentially modifiable but frequently under-recognized determinant of adverse cardiovascular outcomes [3].

Nutritional status has emerged as an important component of cardiovascular risk assessment. Malnutrition is no longer understood solely as undernutrition or low body weight; rather, it encompasses inadequate nutrient intake or uptake, altered body composition, and impaired physiological function, and may occur even among individuals with normal or elevated body mass index (BMI) [4]. According to the European Society for Clinical Nutrition and Metabolism (ESPEN), malnutrition results from insufficient nutrient intake or assimilation, leading to changes in body composition and adverse clinical outcomes [5]. Among hospitalized adults, malnutrition is highly prevalent, affecting approximately 20% to 50% of patients, but it often remains underdiagnosed in routine clinical practice [5-8]. In patients with cardiovascular disease, malnutrition may further contribute to systemic inflammation, metabolic dysregulation, impaired recovery, and progression of atherosclerotic disease.

BMI, while frequently utilized as a basic indicator of nutritional status, possesses significant limitations in patients in clinical settings. It fails to accurately represent body composition, tissue mass, or inflammatory load and may be influenced by fluid retention or edema, especially in patients with cardiac conditions [9]. To address these shortcomings, objective nutritional assessment instruments like the Nutritional Risk Index (NRI) and the Geriatric NRI (GNRI) have been created [10-12]. These indices integrate blood albumin and weight-based metrics, facilitating the practical evaluation of nutritional risk in hospitalized patients. Serum albumin serves as both an indicator of nutritional reserve and a reflection of systemic inflammation and disease severity [13]. The interplay among malnutrition, inflammation, and atherosclerosis is termed the malnutrition-inflammation-atherosclerosis (MIA) syndrome, wherein inadequate nutritional status may serve as an indicator of inflammatory activity and may correlate with more severe and intricate coronary artery involvement [14].

The structural severity and complexity of coronary artery disease (CAD) are typically evaluated using the SYNTAX Score (SS), a lesion-based angiographic scoring system that measures the breadth and intricacy of coronary lesions [15]. The correlation between traditional risk factors and atherosclerotic burden is well established; however, the association between nutritional risk and the angiographic severity of CAD in individuals with ACS is inadequately characterized [3]. Several international studies have reported that lower NRI or GNRI scores are associated with more extensive coronary involvement and poorer cardiovascular outcomes [4,16,17]. Although previous international studies have examined the association between nutritional risk indices and angiographic severity of CAD, evidence from Bangladesh remains scarce, particularly among patients with ACS undergoing coronary angiography during index hospitalization.

In Bangladesh, cardiovascular disease is increasing rapidly, and hospital admissions due to CAD are rising [18]. At the same time, malnutrition remains a persistent public health concern despite improvements in food security and population health indicators. The coexistence of these two burdens makes the evaluation of nutritional status in ACS patients particularly relevant in the Bangladeshi context. However, local evidence examining the association between NRI/GNRI and angiographic severity of CAD, particularly using the SS, is scarce.

Assessment of nutritional risk in patients with ACS may offer a simple, low-cost, and clinically relevant approach for assessment of nutritional risk and angiographic severity, particularly in resource-limited settings. Lower NRI/GNRI scores may reflect poorer nutritional reserve, systemic inflammation, and greater metabolic vulnerability, which may be associated with more complex coronary artery involvement. Therefore, evaluating these indices may provide additional insight into the association between nutritional risk and angiographic severity of CAD in patients with ACS, particularly in resource-limited settings where locally generated evidence remains scarce. Considering the limited evidence from Bangladesh, this study aimed to evaluate the association between nutritional risk indices (NRI/GNRI) and angiographic severity of CAD, assessed by the SS, among patients with ACS. The secondary objectives were to determine the proportion of patients with nutritional risk, assess the adjusted association between nutritional index scores and SS, and explore the discriminatory ability of NRI/GNRI for identifying high-risk SSs, including receiver operating characteristic (ROC)-derived cut-off values and comparison with serum albumin.

Materials And Methods

Study design and setting

This cross-sectional study was carried out at the Department of Cardiology at Chittagong Medical College

Hospital (CMCH), Chattogram, Bangladesh, from April 2024 to March 2025. The Ethical Review Committee of Chittagong Medical College accepted the study protocol (Memo No. 59.27.0000.013.19.PG.2024/1065). The study objectives, procedures, potential risks, and benefits were explained to each participant. Written informed consent was obtained before enrolment. Participation was voluntary, and the anonymity of all gathered information was preserved throughout the study.

Study population, sample size, and sampling

The study population included admitted patients with ACS who underwent coronary angiography during the index hospitalization. Consecutive sampling was followed, and all eligible patients who fulfilled the selection criteria and provided informed written consent were enrolled. The sample size was estimated to detect a significant correlation between the NRI and SS, as the primary outcome was the relationship between nutritional status and angiographic severity of CAD. Using a previously reported correlation coefficient of −0.328 between nutritional index and SS [3], with a 5% level of significance and 95% power, the minimum required sample size was calculated to be 115. However, 140 eligible patients were enrolled during the study period and included in the final analysis.

Eligibility criteria

The study included patients diagnosed with ACS who were hospitalized at CMCH and underwent coronary angiography. Patients with a previous history of PCI or coronary artery bypass grafting (CABG) were excluded. Additional exclusion criteria included systemic inflammatory illness, renal failure (estimated glomerular filtration rate (eGFR) <30 mL/min/1.73 m^2 or requirement for dialysis), hepatic failure (clinically documented decompensated liver cirrhosis or hepatic dysfunction with impaired synthetic function), severe heart failure (New York Heart Association (NYHA) functional class III-IV), hypothyroidism, and hyperthyroidism. These exclusion criteria were applied to minimize potential confounding effects on serum albumin levels, nutritional status, and angiographic severity assessment.

Data collection procedure

After enrollment, demographic information, cardiovascular risk factors, clinical history, type of ACS, and relevant clinical findings were recorded using a structured case record form (Appendix A). Hypertension, diabetes mellitus, dyslipidemia, and obesity were recorded as binary variables (present/absent) based on the patients' previously known diagnoses, as obtained from their clinical history. Height and body weight were measured before coronary angiography. Blood samples were collected within 24 hours of admission for serum albumin, fasting blood glucose, and lipid profile. Serum albumin was measured by the bromocresol green method using a Beckman-Coulter AU480 analyzer (Beckman Coulter Inc., Miami, FL, USA). Fasting blood glucose, triglycerides, total cholesterol, high-density lipoprotein (HDL) cholesterol, and low-density lipoprotein (LDL) cholesterol were measured using standard laboratory methods on the Beckman-Coulter AU480 analyzer.

Assessment of nutritional status

NRI was calculated for patients aged below 65 years using the following formula [19]:

$$\mathrm{NRI}=15.19\times\text{Serum albumin (g/dL)}+41.7\times\frac{\text{Actual body weight (kg)}}{\text{Ideal body weight (kg)}}$$

For patients aged 65 years or above, the GNRI was calculated using the following formula:

$$\mathrm{GNRI}=14.89\times\text{Serum albumin (g/dL)}+41.7\times\frac{\text{Actual body weight (kg)}}{\text{Ideal body weight (kg)}}$$

Ideal body weight was calculated using the sex-specific Lorentz formula: height (cm) − 100 − [(height (cm) − 150)/4] for men and height (cm) − 100 − [(height (cm) − 150)/2.5] for women. For the calculation of the GNRI, the ratio of actual body weight to ideal body weight was capped at 1.0 when actual body weight exceeded ideal body weight, in accordance with the original GNRI methodology [10].

NRI and GNRI were applied according to patient age and combined for exploratory association analyses, as both indices incorporate serum albumin and body weight-related parameters to assess nutritional risk. Based on the NRI/GNRI score, patients were categorized into three nutritional risk groups: no nutritional risk (>98), low nutritional risk (92-98), and high nutritional risk (<92) [10-12].

Coronary angiography and assessment of CAD severity

Coronary angiography was performed during the index hospitalization through the transradial approach using the Trinias system for interventional angiography (Shimadzu Corporation, Kyoto, Japan). Angiographic severity and complexity of CAD were assessed by SS [15]. Angiographic images were reviewed by two experienced cardiologists who were blinded to the nutritional status and baseline clinical information of the patients. Any discrepancies in SS assessment between the two cardiologists were resolved through joint review of the angiographic images and consensus. Patients were classified into the low-risk score (≤22), intermediate-risk score (23-32), and high-risk score (≥33) groups [20]. Multivessel disease, left main disease, thrombus, long lesion, and chronic total occlusion were also recorded where present.

Statistical analysis

Data were analyzed using IBM SPSS Statistics version 23.0 (IBM Corp., Armonk, NY, USA). Dwass-Steel-Critchlow-Fligner (DSCF) post hoc pairwise comparisons were performed using jamovi version 2.7.41 (The jamovi project, Sydney, Australia). Quantitative variables were expressed as mean ± standard deviation or median with interquartile range (IQR), according to data distribution. Categorical variables were expressed as frequency and percentage. Categorical variables were compared using the Chi-squared test or Fisher's exact test, as appropriate. One-way ANOVA was used to compare normally distributed continuous variables among nutritional risk groups. The Kruskal-Wallis test was used to compare non-normally distributed continuous variables across nutritional risk groups, followed by DSCF post hoc pairwise comparisons, where appropriate. Spearman's rank correlation analysis was performed to assess the association of SS with the combined NRI/GNRI scores and serum albumin levels. To assess the robustness of the pooled association, an age-stratified sensitivity analysis was performed using Spearman's rank correlation separately for patients aged below 65 years and those aged 65 years or above. Multivariable linear regression analysis was performed with SS as the dependent variable. Age, sex, serum albumin, NRI/GNRI score, smoking status, hypertension, diabetes mellitus, dyslipidemia, family history of CAD, and ACS type were included as independent variables based on their clinical relevance and potential confounding effects. ACS type was treated as a categorical variable, with unstable angina as the reference category. Model fit was evaluated using R^2, while multicollinearity was assessed using variance inflation factor (VIF) and tolerance values. ROC curve analysis was performed to evaluate the predictive performance of NRI and serum albumin for identifying high-risk SS. The areas under the ROC curves (AUCs) were compared using DeLong's test to assess the statistical significance of differences in discriminatory performance. A p-value of <0.05 was considered statistically significant.

Results

Among the 140 study patients, 118 (84.3%) were aged <65 years and 22 (15.7%) were aged ≥65 years. The mean age was 54.2 ± 10.4 years, ranging from 22.0 to 90.0 years. Male patients predominated, comprising 113 (80.7%) of the study population, while 27 (19.3%) were female. Hypertension was the most frequent cardiovascular risk factor, observed in 84 (60.0%) patients, followed by dyslipidemia in 78 (55.7%), diabetes mellitus in 55 (39.3%), and current or previous smoking in 44 (31.4%) patients. Family history of CAD and obesity were each present in nine (6.4%) patients (Table *1*).

Demographic characteristics and cardiovascular risk factors		Values
Age (years)	<65	118 (84.3)
	≥65	22 (15.7)
	Mean ± SD	54.2 ± 10.4
	Range	22.0-90.0
Gender	Male	113 (80.7)
	Female	27 (19.3)
Hypertension		84 (60.0)
Dyslipidemia		78 (55.7)
Diabetes mellitus		55 (39.3)
Ex-/current smoker		44 (31.4)
Family history of CAD		9 (6.4)
Obesity		9 (6.4)

TABLE 1: Demographic characteristics and cardiovascular risk factors of the study patients (N = 140)

Data presented as frequency (percentage), mean ± SD, range

SD: standard deviation; CAD: coronary artery disease

In terms of clinical presentation, ST-segment elevation myocardial infarction (STEMI) was the predominant diagnosis, occurring in 86 (61.4%) patients, followed by non-STEMI (NSTEMI) in 34 (24.3%) and unstable angina in 20 (14.3%) patients. The mean serum albumin level was 3.85 ± 0.51 g/dL. The mean fasting blood sugar was 7.17 ± 3.03 mmol/L, while the mean triglyceride, total cholesterol, HDL cholesterol, and LDL cholesterol levels were 157.71 ± 47.40 mg/dL, 191.74 ± 42.24 mg/dL, 40.47 ± 6.89 mg/dL, and 126.51 ± 37.17 mg/dL, respectively (Table *2*).

Variables		Values
Clinical presentation	STEMI	86 (61.4)
	NSTEMI	34 (24.3)
	Unstable angina	20 (14.3)
Biochemical profile	Serum albumin (g/dL)	3.85 ± 0.51
	Fasting blood sugar (mmol/L)	7.17 ± 3.03
	Triglyceride (mg/dL)	157.71 ± 47.40
	Total cholesterol (mg/dL)	191.74 ± 42.24
	HDL cholesterol (mg/dL)	40.47 ± 6.89
	LDL cholesterol (mg/dL)	126.51 ± 37.17

TABLE 2: Clinical presentation and biochemical profile of the study patients (N = 140)

Data presented as frequency (percentage), mean ± SD

STEMI: ST-segment elevation myocardial infarction; NSTEMI: non-ST-segment elevation myocardial infarction; HDL: high-density lipoprotein; LDL: low-density lipoprotein; SD: standard deviation

The nutritional assessment revealed that 79 (56.4%) patients had no nutritional risk, while 32 (22.9%) had low nutritional risk and 29 (20.7%) had high nutritional risk according to the NRI/GNRI score. Thus, 61 (43.6%) patients had some degree of nutritional risk. The mean NRI/GNRI score was 100.52 ± 9.58, ranging from 79.15 to 120.98. Angiographic evaluation showed a median SS of 18.00 (IQR: 9.00-25.25), with most patients categorized as low-risk SS (93 (66.4%)). Intermediate-risk and high-risk SSs were observed in 33 (23.6%) and 14 (10.0%) patients, respectively (Figure *1*). Multivessel disease was present in 101 (72.1%) patients and left main disease in six (4.3%) patients.

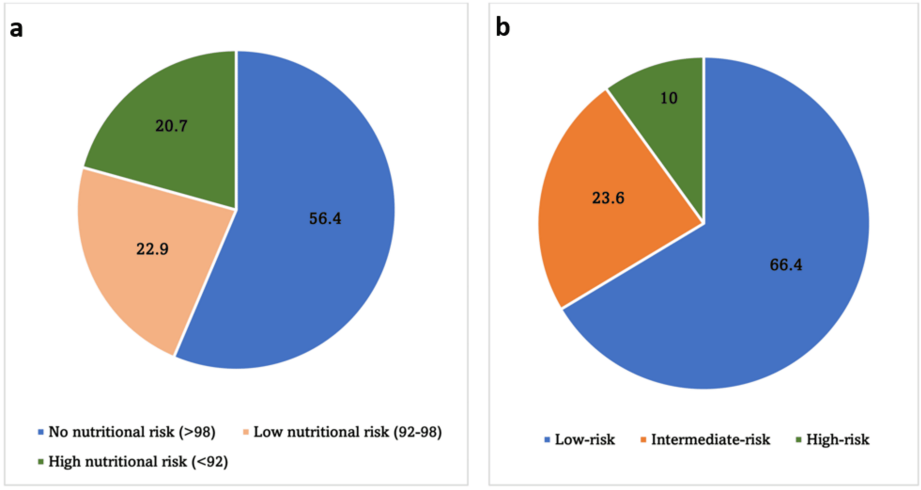


FIGURE 1: (a) Nutritional risk status and (b) angiographic severity of coronary artery disease by SYNTAX Score of the study participants

The mean SS was higher among patients with high nutritional risk (25.35 ± 9.54) and low nutritional risk (24.61 ± 7.69) compared with those without nutritional risk (12.79 ± 8.89). Similarly, the median SS was 25.00, 24.50, and 10.00 in the high-, low-, and no-risk groups, respectively. Post hoc pairwise comparisons using the DSCF test demonstrated significantly higher SSs in both low- and high-risk groups compared with the no-risk group (both $p < 0.001$), while no significant difference was observed between the low- and high-risk groups ($p = 0.994$) (Figure *2*).

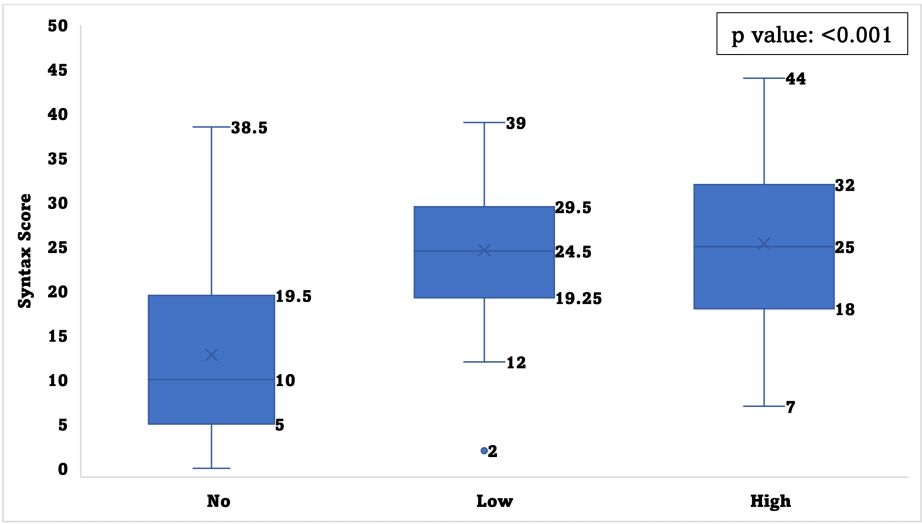


FIGURE 2: Distribution of SYNTAX Score according to the Nutritional Risk Index (NRI)/Geriatric Nutritional Risk Index (GNRI)

Kruskal-Wallis test and post hoc pairwise comparisons using the Dwass-Steel-Critchlow-Fligner (DSCF) test were done

Patients with nutritional risk were older and had a higher burden of hypertension than those without nutritional risk. Mean age increased from 50.6 ± 9.5 years in the no-risk group to 58.9 ± 8.9 and 58.6 ± 8.9

years in the low- and high-risk groups, respectively (p < 0.001). Hypertension was significantly more frequent in the low-risk (24 (75.0%)) and high-risk (21 (72.4%)) groups than in the no-risk group (39 (49.4%)) (p = 0.014). Clinical presentation also differed significantly across groups (p = 0.021), while serum albumin showed a progressive decline from 4.14 ± 0.34 g/dL to 3.66 ± 0.27 g/dL and 3.27 ± 0.47 g/dL across no-, low-, and high-risk groups, respectively (p < 0.001). Multivessel disease was significantly more common among patients with low (30 (93.8%)) and high (25 (86.2%)) nutritional risk than those without nutritional risk (46 (58.2%)) (p < 0.001). Similarly, high-risk SS was more frequent in the low-risk (6 (18.8%)) and high-risk (6 (20.7%)) groups compared with the no-risk group (2 (2.5%)) (p < 0.001) (Table 3).

Variables		Nutritional risk status			p-value
		No risk (>98)	Low risk (92-98)	High risk (<92)	
		(n = 79)	(n = 32)	(n = 29)	
Age (years)		50.6 ± 9.5	58.9 ± 8.9	58.6 ± 8.9	<0.001[a]
Gender	Male	67 (84.8)	26 (81.3)	20 (69.0)	0.180[b]
	Female	12 (15.2)	6 (18.8)	9 (31.0)	
Ex-/current smoker		21 (26.6)	13 (40.6)	10 (34.5)	0.326[b]
Hypertension		39 (49.4)	24 (75.0)	21 (72.4)	0.014[b]
Diabetes mellitus		25 (31.6)	14 (43.8)	16 (55.2)	0.057[b]
Dyslipidemia		40 (50.6)	22 (68.8)	16 (55.2)	0.219[b]
Family history of coronary artery disease		7 (8.9)	2 (6.3)	0 (0)	0.250[b]
Obesity		8 (10.1)	0 (0)	1 (3.4)	0.110[b]
Clinical presentation	STEMI	50 (63.3)	16 (50.0)	20 (69.0)	0.021[b]
	NSTEMI	13 (16.5)	13 (40.6)	8 (27.6)	
	Unstable angina	16 (20.3)	3 (9.4)	1 (3.4)	
Serum albumin (g/dL)		4.14 ± 0.34	3.66 ± 0.27	3.27 ± 0.47	<0.001[a,x,y,z]
Fasting blood sugar (mmol/L)		6.94 ± 3.02	7.15 ± 2.86	7.82 ± 3.21	0.414[a]
Triglyceride (mg/dL)		161 ± 50	156 ± 43	147 ± 42	0.386[a]
Total cholesterol (mg/dL)		186 ± 40	201 ± 43	194 ± 43	0.252[a]
HDL-C (mg/dL)		41 ± 7	40 ± 7	39 ± 7	0.241[a]
LDL-C (mg/dL)		121 ± 35	133 ± 35	131 ± 42	0.196[a]
CAG findings	Multivessel disease (MVD)	46 (58.2)	30 (93.8)	25 (86.2)	<0.001[b]
	Left main disease (LMD)	2 (2.5)	2 (6.3)	2 (6.9)	0.503[b]
Angiographic severity of coronary artery by SYNTAX Score	Low risk (≤22)	68 (86.1)	12 (37.5)	13 (44.8)	<0.001[b]
	Intermediate risk (23-32)	9 (11.4)	14 (43.8)	10 (34.5)	
	High risk (≥33)	2 (2.5)	6 (18.8)	6 (20.7)	

TABLE 3: Characteristics of acute coronary syndrome patients according to nutritional risk category

Data presented as mean ± SD, or frequency (%)

HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; STEMI: ST-segment elevation myocardial infarction; NSTEMI: non-ST-segment elevation myocardial infarction; CAG: coronary angiography; SD: standard deviation

[a]ANOVA was done

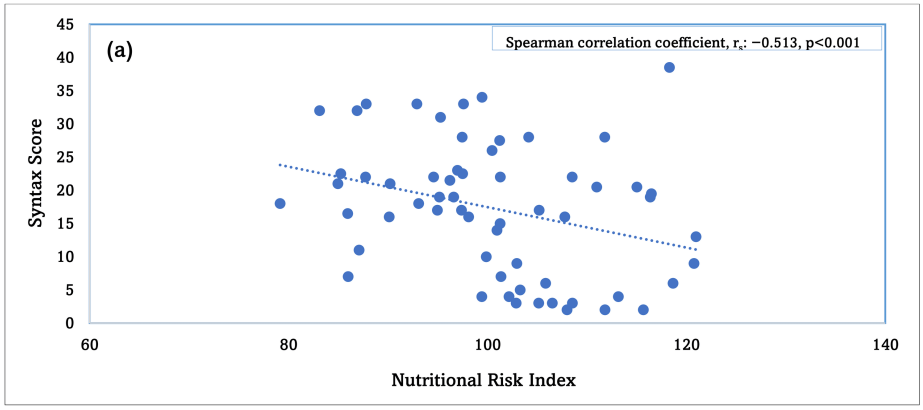
[b]Chi-squared test was done

[x]Significant differences were found between no risk (>98) and low risk (92-98)

[y]Significant differences were found between no risk (>98) and high risk (<92)

[z]Significant differences were found between low risk (92-98) and high risk (<92)

There was a significant moderate negative correlation between NRI/GNRI score and SS ($r_s = -0.513$; $p < 0.001$), suggesting that poorer nutritional status was associated with greater angiographic severity of CAD (Figure 3). Age-stratified sensitivity analysis demonstrated a significant moderate negative correlation between NRI and SS among patients aged below 65 years (n = 118; $r_s = -0.496$, $p < 0.001$). Among patients aged 65 years or above, GNRI showed a weak negative correlation with SS, which was not statistically significant (n = 22; $r_s = -0.198$, $p = 0.377$) (Appendix B). Serum albumin also demonstrated a significant moderate negative correlation with SS (rho = −0.455; $p < 0.001$), although the strength of this association was lower than that observed for NRI/GNRI (Figure 3).



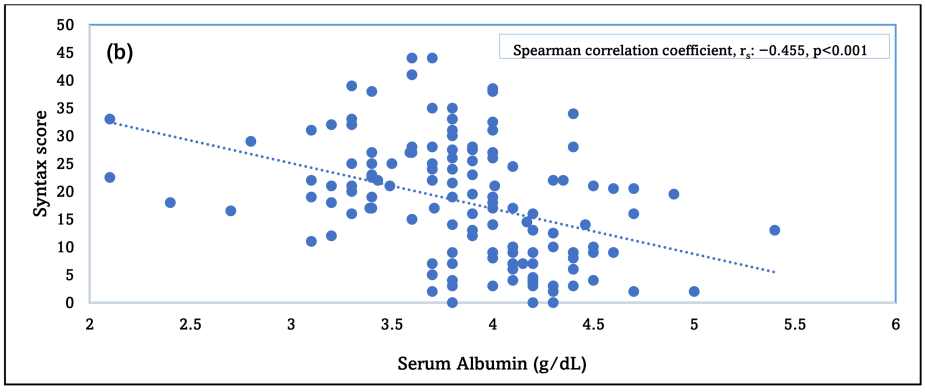


FIGURE 3: (a) Correlation between Nutritional Risk Index and angiographic severity of coronary artery disease as assessed by SYNTAX Score and (b) correlation between serum albumin and angiographic severity of coronary artery disease as assessed by the SYNTAX Score

Spearman correlation test was done

ROC curve analysis showed that serum albumin had poor discriminatory ability for predicting high-risk SS (≥33), with an AUC of 0.664 (95% confidence interval (CI): 0.537-0.792; p = 0.044). NRI/GNRI score showed

acceptable predictive performance, with an AUC of 0.742 (95% CI: 0.612-0.872; p = 0.003). At a cut-off value of ⩽96.18, the NRI score demonstrated 78.6% sensitivity and 72.2% specificity for identifying high-risk SS. Although NRI/GNRI showed a numerically higher AUC than serum albumin, DeLong's test revealed no statistically significant difference between their discriminatory performances (AUC difference = 0.0777, 95% CI: −0.0436 to 0.199; p = 0.209) (Figure 4).

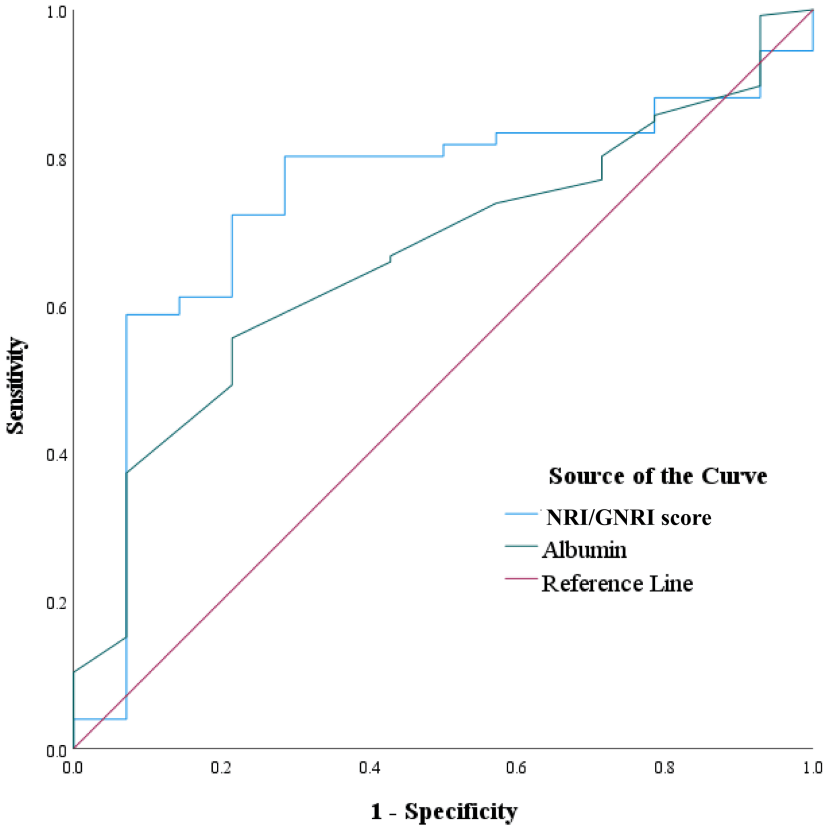


FIGURE 4: ROC curve analysis of NRI/GNRI score and serum albumin for predicting high-risk SYNTAX Score

NRI: Nutritional Risk Index; GNRI: Geriatric Nutritional Risk Index; ROC: receiver operating characteristic

Multivariable linear regression analysis demonstrated that the model explained 36.3% of the variability in SS (R = 0.603, R^2 = 0.363). After adjustment for age, serum albumin, smoking status, hypertension, dyslipidemia, diabetes mellitus, ACS type, family history of CAD, and sex, the NRI/GNRI score remained significantly negatively associated with SS (B = −0.386, 95% CI: −0.624 to −0.149; p = 0.002), indicating that each one-point increase in nutritional index score was associated with an estimated 0.386-point decrease in SS. Current or former smoking (B = 5.400, 95% CI: 1.970-8.831; p = 0.002) and dyslipidemia (B = 3.295, 95% CI: 0.144-6.445; p = 0.041) were significantly associated with higher SSs. Male sex was significantly associated with a lower SS compared with female sex (B = −4.875, 95% CI: −9.118 to −0.632; p = 0.025). Age, serum albumin, hypertension, diabetes mellitus, ACS type, and family history of CAD showed no statistically significant associations with SS (all p > 0.05). No substantial multicollinearity was detected, with VIF values ranging from 1.06 to 1.54 (Table 4).

Variables	B	SE	95% CI	p-value
Age (years)	0.124	0.088	−0.050 to 0.298	0.160
Serum albumin	−0.451	2.256	−4.916 to 4.014	0.842
NRI/GNRI score	−0.386	0.120	−0.624 to −0.149	0.002
Current/former smoking	5.400	1.734	1.970 to 8.831	0.002
Hypertension	0.795	1.677	−2.524 to 4.114	0.636
Dyslipidemia	3.295	1.592	0.144 to 6.445	0.041
Diabetes mellitus	1.250	1.655	−2.026 to 4.526	0.452
STEMI vs. unstable angina	2.034	2.413	−2.740 to 6.807	0.401
NSTEMI vs. unstable angina	4.110	2.788	−1.407 to 9.627	0.143
Family history of CAD	1.614	3.378	−5.069 to 8.297	0.634
Male	−4.875	2.144	−9.118 to −0.632	0.025

TABLE 4: Multivariable linear regression analysis of factors associated with SYNTAX Score among patients with acute coronary syndrome (N = 140)

Model fit: R = 0.603; R^2 = 0.363. Multicollinearity was assessed using variance inflation factor (VIF) and tolerance values. VIF values ranged from 1.06 to 1.54, indicating no substantial multicollinearity

CAD: coronary artery disease; NRI: Nutritional Risk Index; GNRI: Geriatric Nutritional Risk Index; STEMI: ST-segment elevation myocardial infarction; NSTEMI: non-ST-segment elevation myocardial infarction; B: unstandardized regression coefficient; SE: standard error; CI: confidence interval

Discussion

This study evaluated the association between nutritional risk indices (NRI/GNRI) and angiographic severity of CAD among patients with ACS. The findings demonstrated a moderate negative association between NRI/GNRI scores and SS, indicating that lower nutritional index scores were associated with greater angiographic severity and complexity of CAD. These findings suggest that nutritional risk indices may serve as potential markers of angiographic disease severity, although their clinical utility requires further validation.

In this study, 43.6% of patients with ACS had some degree of nutritional risk at admission, of whom 20.7% were classified as high risk. This finding is comparable to international data. Tonet et al., for example, reported a 44% prevalence of malnutrition among elderly patients with ACS [21]. Other studies using different nutritional assessment indices, such as the Controlling Nutritional Status (CONUT) score and the NRI, have reported prevalence rates ranging from 50% to 60% in ACS cohorts [4,12]. Kalyoncuoğlu et al. observed a wide variation in the prevalence of nutritional risk among elderly patients with CAD, ranging from 6.3% when assessed by the prognostic nutritional index (PNI) to more than 60% when assessed by the GNRI and CONUT score [22]. Similarly, Raposeiras Roubín et al. reported malnutrition prevalence between 50% and 60% among patients with ACS based on CONUT, PNI, and NRI scores [12]. Therefore, the present findings support the growing body of evidence that nutritional risk is highly prevalent among patients with ACS and should not be regarded as an uncommon or incidental finding. The high prevalence observed in this Bangladeshi cohort further underscores the need for routine nutritional screening in clinical cardiology, a practice that remains underutilized in routine care [12].

Patients with low and high nutritional risk were older than those without nutritional risk, although mean age was comparable between the two nutritional risk groups. This suggests that advancing age was closely associated with nutritional vulnerability among patients with ACS. Age-related physiological decline, reduced appetite and dietary intake, multiple comorbidities, frailty, and greater inflammatory burden may collectively contribute to impaired nutritional status during acute cardiovascular illness. In parallel, serum albumin showed a significant stepwise decline across nutritional risk categories, reaching the lowest level in the high-risk group. As albumin reflects both nutritional reserve and systemic inflammatory status, this finding further supports the presence of greater biological stress among nutritionally vulnerable patients.

The association between nutritional risk and greater angiographic severity of CAD may be partly explained by the MIA pathway. In this framework, poor nutritional status may reflect systemic inflammation [14], which can suppress hepatic albumin synthesis and promote pro-inflammatory cytokine release, contributing

to appetite suppression, catabolism, endothelial dysfunction, atherosclerotic progression, and plaque instability [23]. As ACS commonly results from atherosclerotic plaque rupture involving chronic inflammatory processes [24], patients with greater nutritional impairment may also have a higher inflammatory and atherosclerotic burden. However, inflammatory biomarkers were not directly assessed in the present study; therefore, the MIA pathway represents a plausible biological mechanism rather than an established explanation for the observed association.

Patients with nutritional risk demonstrated significantly higher SSs than those without nutritional risk. However, no significant difference was observed between the low- and high-risk groups (p = 0.994), suggesting that the presence of nutritional risk, rather than a progressive increase in its severity, was associated with greater angiographic complexity. This finding may reflect an underlying inflammatory and metabolic milieu associated with more extensive atherosclerotic involvement. A key finding of this study is the significant moderate negative correlation (rho = -0.513, p < 0.001) between NRI/GNRI scores and the SS. This suggests that lower nutritional index scores were associated with greater complexity and extent of coronary atherosclerosis. This is consistent with previous research by Kurmus et al., who also identified a negative association between NRI and the SS [25]. In this study, multivariable linear regression analysis demonstrated that the NRI/GNRI score remained significantly negatively associated with SS after adjustment for relevant clinical factors (B = −0.386, 95% CI: −0.624 to −0.149; p = 0.002). Each one-point increase in the nutritional index score was associated with an estimated 0.386-point decrease in SS. Smoking (B = 5.400; p = 0.002) and dyslipidemia (B = 3.295; p = 0.041) were significantly associated with higher SSs, whereas male sex was associated with lower scores (B = −4.875; p = 0.025). The model explained 36.3% of the variability in SS. These findings suggest that nutritional risk indices may reflect angiographic disease complexity independently of several established cardiovascular risk factors, although causal inference is limited by the cross-sectional design.

Age-stratified sensitivity analysis further demonstrated a significant moderate negative correlation between NRI and SS among patients aged below 65 years (r_s = −0.496, p < 0.001). In contrast, a weaker, statistically non-significant negative correlation was observed between GNRI and SS among patients aged 65 years or above (r_s = −0.198, p = 0.377). Although the direction of association was consistent across both age groups, the overall finding was predominantly supported by the younger subgroup. The non-significant association in the older subgroup may partly reflect its relatively small sample size (n = 22), highlighting the need for further investigation in larger age-specific populations.

The exploratory ROC analysis demonstrated moderate discriminatory ability of NRI/GNRI for identifying high-risk SSs (AUC = 0.742, 95% CI: 0.612-0.872). At a cut-off value of ≤96.18, sensitivity and specificity were 78.6% and 72.2%, respectively. Although these findings suggest potential value as a marker of angiographic disease severity, the small number of high-risk patients (n = 14), absence of external validation, and cross-sectional design limit their immediate clinical applicability. Larger prospective studies are necessary to establish the clinical utility of these indices.

Strengths of the study

This study had several methodological strengths. It provided context-specific evidence from Bangladesh regarding the association between nutritional risk indices and angiographic severity of CAD among patients with ACS. Consecutive patient enrollment reduced the potential for investigator-driven selection bias, while the use of established nutritional assessment indices (NRI/GNRI) provided a simple and objective approach to evaluating nutritional risk. Serum albumin was measured using a standardized laboratory method, and CAD severity was assessed using the SS by two experienced cardiologists blinded to patients' nutritional status, reducing the potential for assessment bias. Furthermore, age-stratified sensitivity analysis and multivariable regression analysis allowed additional exploration of the association between nutritional risk and angiographic severity. These features strengthened the methodological consistency and clinical relevance of the study findings.

Limitations

The study had several limitations. First, it was conducted at a single tertiary-level hospital with a relatively small sample size, which may limit the generalizability of the findings. Only 14 patients had high-risk SSs, reducing the precision and reliability of the exploratory ROC analysis. Furthermore, the inclusion of only patients undergoing coronary angiography may have introduced selection bias. Nutritional status was assessed using NRI/GNRI without comprehensive evaluation of dietary intake, body composition, or micronutrient status. Serum albumin levels may have been influenced by acute inflammation, myocardial injury, and disease severity, potentially reflecting acute disease burden rather than nutritional reserve alone. The absence of inflammatory biomarkers also prevented direct evaluation of the proposed MIA pathway. Combining NRI and GNRI, which have different calculation methods and established classification thresholds, may have introduced measurement heterogeneity and potential nutritional risk misclassification. Although age-stratified sensitivity analysis was performed, the small older subgroup (n = 22) and absence of age-stratified multivariable regression limited further assessment of the consistency of associations across age groups. Additionally, formal interobserver agreement for SYNTAX scoring was not quantified. Although the multivariable regression model adjusted for several established cardiovascular risk

factors, including diabetes mellitus, smoking, dyslipidemia, hypertension, sex, and ACS type, residual confounding from unmeasured factors such as socioeconomic status, dietary habits, medication use, and physical activity could not be excluded. Furthermore, serum albumin was included alongside NRI/GNRI despite being a component of these indices. Although VIF values indicated no substantial multicollinearity, the conceptual overlap between these variables warrants cautious interpretation. Comprehensive regression residual diagnostics were not available, limiting the assessment of model assumptions. Information regarding fibrinolytic treatment before coronary angiography and the interval between hospital admission and angiography was not systematically recorded, limiting assessment of their potential influence on angiographic findings and SS. Moreover, the reliance on body weight-related measurements and the exclusion of patients with severe heart failure may restrict the applicability of these findings to patients with fluid retention or advanced cardiac dysfunction. Finally, the cross-sectional design precluded causal inference, and the findings require validation in larger, multicenter prospective studies.

Conclusions

This study demonstrated that nutritional risk was common among patients with ACS and was significantly associated with greater angiographic severity and complexity of CAD. Patients with lower NRI/GNRI scores exhibited higher SSs and more frequent multivessel coronary involvement, suggesting that impaired nutritional status may reflect a greater burden of coronary atherosclerosis. A significant moderate negative correlation was observed between nutritional index scores and SS, and this association persisted after adjustment for selected clinical factors. Although NRI/GNRI may provide simple, accessible, and low-cost measures for assessing nutritional risk in patients with ACS, their discriminatory performance for identifying severe angiographic CAD remains exploratory and requires further validation. Given the cross-sectional design and limited number of patients with high-risk SSs, these findings should be interpreted cautiously. Larger, multicenter prospective studies incorporating comprehensive nutritional assessments and clinical outcomes are warranted to validate these associations and determine the potential utility of NRI/GNRI in cardiovascular risk stratification before their incorporation into routine clinical decision-making.

Appendices

Appendix A

A	Patient identification	
1	ID No.:	
2	Mobile No.:	
3	Date of admission:	
4	Date of coronary angiogram:	
B	Demographic information	
1	Age (years): _____	
2	Gender	1 = male, 2 = female
C	Risk factors	
1	Ex- or current smoker	1 = yes, 2 = no
2	Hypertension	1 = yes, 2 = no
3	Diabetes mellitus	1 = yes, 2 = no
4	Dyslipidemia	1 = yes, 2 = no
5	Obesity	1 = yes, 2 = no
7	Family history of CAD	1 = yes, 2 = no
D	Physical examination	
1	Height	_____ (m)
2	Weight	_____ (kg)
E	Variables related to ACS	
1	Type of ACS	STEMI = 1, NSTEMI = 2, UA = 3
F	Laboratory parameters	

1	Serum albumin	_____ (g/dL)
2	Fasting blood sugar	_____ (mmol/L)
3	S. triglyceride	_____ (mg/dL)
4	S. total cholesterol	_____ (mg/dL)
5	S. HDL cholesterol	_____ (mg/dL)
6	S. LDL cholesterol	_____ (mg/dL)
G	Nutritional assessment	
1	NRI/GNRI score	
H	Variable-related angiographic severity	
1	Multivessel diseases	1 = yes, 2 = no
2	Left main disease	1 = yes, 2 = no
3	Heavy calcification	1 = yes, 2 = no
4	Thrombus	1 = yes, 2 = no
5	Long lesion	1 = yes, 2 = no
6	Chronic total occlusion	1 = yes, 2 = no
7	SYNTAX Score	

TABLE 5: Case record form

CAD: coronary artery disease; ACS: acute coronary syndrome; STEMI: ST-segment elevation myocardial infarction; NSTEMI: non-ST-segment elevation myocardial infarction; UA: unstable angina; HDL: high-density lipoprotein; LDL: low-density lipoprotein; NRI: Nutritional Risk Index; GNRI: Geriatric Nutritional Risk Index

Appendix B

Age group	n	r_s	p-value
Overall (NRI/GNRI)	140	−0.513	<0.001
<65 years (NRI)	118	−0.496	<0.001
≥65 years (GNRI)	22	−0.198	0.377

TABLE 6: Age-stratified sensitivity analysis of the association between nutritional risk indices and SYNTAX Score among patients with acute coronary syndrome (N = 140)

Spearman's rank correlation test was performed

NRI: Nutritional Risk Index; GNRI: Geriatric Nutritional Risk Index; r_s: Spearman correlation coefficient

Age-stratified sensitivity analysis revealed a significant moderate negative correlation between NRI/GNRI and SYNTAX Score in the overall population ($r_s = -0.513$, $p < 0.001$). Among patients aged below 65 years, NRI showed a significant moderate negative correlation with SYNTAX Score ($r_s = -0.496$, $p < 0.001$), whereas GNRI demonstrated a weak, non-significant negative correlation among patients aged 65 years or above ($r_s = -0.198$, $p = 0.377$). These findings indicated that lower nutritional index scores were associated with greater angiographic severity, with statistical significance observed only in the younger subgroup.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the

work.

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Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Ethical Review Committee of Chittagong Medical College issued approval 59.27.0000.013.19.PG.2024/1065. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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